Fraunhofer

LIGHT & SURFACES

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FRAUNHOFER GROUP FOR LIGHT & SURFACES
SMART SURFACES

CONTENTS

SURFACES – SURFACE TECHNOLOGY DRIVES NUMEROUS INNOVATIONS

Within the Fraunhofer Group for Light & Surfaces, six Fraunhofer institutes cooperate in the fields of lasers, optics, metrology and coating technology. The institutes combine complementary skills in the following areas: laser manufacturing techniques, beam sources, metrology, medicine and life sciences, optical systems and optics manufacturing, EUV technology, process and system simulation, materials technology, micro- and nanotechnologies, and thin-film, plasma and electron beam technology.

Competency by networking

Building on their basic research in the various fields of application, the institutes work together to supply fast, flexible and customer-specific system solutions in the fields of coating technology and photonics. Strategy is coordinated to reflect current market requirements, yielding synergies that benefit the customer. The institutes also collaborate with their local universities to provide the full range of student education, up to and including doctoral studies. As a result, the Fraunhofer institutes are not only partners to technological development, but also a continuous source of new talent in the fields of coating technology and photonics.

Core competencies of the group

The Fraunhofer institutes' competencies are coordinated to ensure that research can be quickly and flexibly adapted to the requirements of the various fields of application:
- Laser manufacturing
- Beam sources
- Metrology
- Medicine and life sciences
- Materials technology
- Optical systems and optics manufacturing
- Micro- and nanotechnologies
- Thin-film technology
- Plasma technology
- Electron beam technology
- EUV technology
- Process and system simulation

Fields of application

The Fraunhofer institutes are able to draw on extensive process expertise to provide customers with tailored, laser- and process-specific solutions that take material and product design, construction, means of production and quality assurance into account. These solutions serve a wide range of industries:
- Automotive
- Biotechnology and life sciences
- Electronics and sensor technology
- Energy and the environment
- Aerospace
- Mechanical and plant engineering, tool and die manufacturing
- Optics

1 Laser nanostructuring.

THE INSTITUTES

Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP

The Fraunhofer FEP works on innovative solutions in the fields of vacuum coating, surface treatment as well as organic semiconductors. The core competencies electron beam technology, sputtering, plasma-activated deposition and high-rate PECVD as well as technologies for organic electronics and IC/system design provide a basis for these activities. Fraunhofer FEP continuously enhances them and makes them available to a wide range of industries: mechanical engineering, transport, biomedical engineering, architecture and preservation, packaging, environment and energy, optics, sensor technology and electronics as well as agriculture.

www.fep.fraunhofer.de/en

Fraunhofer Institute for Laser Technology ILT

With more than 400 employees the Fraunhofer ILT develops innovative laser beam sources, laser technologies, and laser systems for its partners from the industry. Our technology areas cover the following topics: laser and optics, medical technology and biophotonics, laser measurement technology and laser material processing. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modeling as well as in the entire system technology.

www.ilt.fraunhofer.de/en

Fraunhofer Institute for Applied Optics and Precision Engineering IOF

The Fraunhofer IOF develops innovative optical systems to control light from the generation to the application. Our service range covers the entire photonic process chain from opto-mechanical and opto-electrical system design to the manufacturing of customized solutions and prototypes. The institute works in the five business fields of Optical Components and Systems, Precision Engineering Components and Systems, Functional Surfaces and Layers, Photonic Sensors and Measuring Systems and Laser Technology.

www.iof.fraunhofer.de/en

Fraunhofer Institute for Physical Measurement Techniques IPM

The Fraunhofer IPM develops tailor-made measuring techniques, systems and materials for industry. In this way we enable our customers to minimize their use of energy and resources while at the same time maximizing quality and reliability. Fraunhofer IPM makes processes more ecological and at the same time more economical. Many years of experience with optical technologies and functional materials form the basis for high-tech solutions in the fields of production control, materials characterization and testing, object and shape detection, gas and process technology as well as functional materials and systems.

www.ipm.fraunhofer.de/en

Fraunhofer Institute for Surface Engineering and Thin Films IST

As an innovative R&D partner the Fraunhofer IST offers complete solutions in surface engineering which are developed in cooperation with customers from industry and research. The IST's »product« is the surface, optimized by modification, patterning, and/or coating for applications in the business units mechanical engineering, tools and automotive technology, aerospace, energy and electronics, optics, and also life science and ecology. The extensive experience of the Fraunhofer IST with thin-film deposition and film applications is complemented by excellent capabilities in surface analysis and in simulating vacuum-based processes.

www.ist.fraunhofer.de/en

Fraunhofer Institute for Material and Beam Technology IWS

The Fraunhofer IWS is known for its innovations in the business units joining and cutting as well as in the surface and coating technology. Across all business units our interdisciplinary topics include energy storage systems, energy efficiency, additive manufacturing, lightweight construction and big data. Our special feature is the expertise of our scientists in combining the profound know-how in materials engineering with the extensive experience in developing system technologies. Every year, numerous solutions with regard to laser material processing and coating technology have been developed and have found their way into industrial applications.

www.iws.fraunhofer.de/en

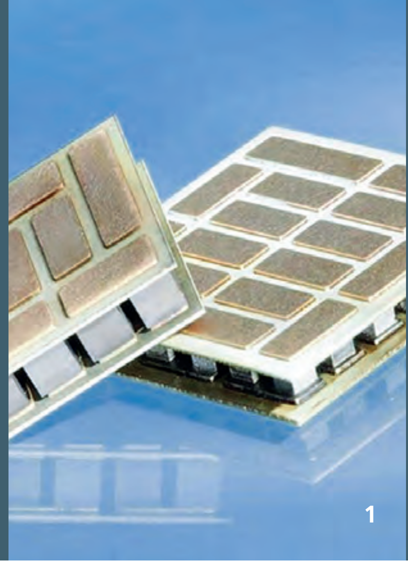
Contact – Fraunhofer Group for Light & Surfaces

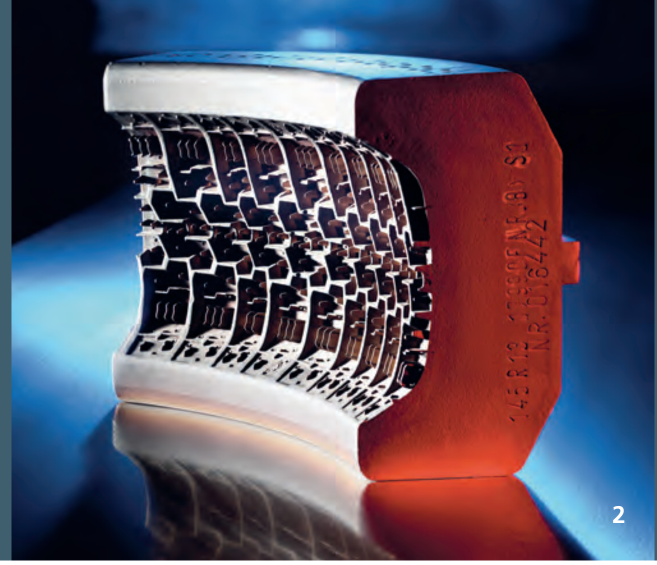
Prof. Reinhart Poprawe (Chairman)
Steinbachstraße 15
52074 Aachen, Germany
reinhart.poprawe@ilt.fraunhofer.de

Dr. Arnold Gillner (Managing Director)
Steinbachstraße 15
52074 Aachen, Germany
arnold.gillner@ilt.fraunhofer.de

www.light-and-surfaces.fraunhofer.de/en

MATERIALS TECHNOLOGY





Materials technology and the characterization of the underlying conditions that goes along with it play a critical role in a manufacturing technique's success. Fortunately, the member institutes of the Fraunhofer Group for Light & Surfaces have access to a range of suitable metrological and material investigation methods. To characterize materials and processing outcomes, researchers employ, for instance, chemical material analysis using X-ray, secondary ion mass and photoelectron spectroscopy, and X-ray fluorescence analysis. The institutes also have access to a broad array of materials developments, including new thermoelectric materials used for energy harvesting, as well as biocompatible materials manufactured using additive techniques. In addition to this materials testing, the group also conducts functional component testing that serves to determine mechanical parameters and identify characteristic curves for the evaluation of endurance and material fatigue.

Applications

- Functional materials
- Materials characterization
- Tribological systems
- Process-adapted materials

FUNCTIONAL MATERIALS

Fraunhofer IOF develops optical materials that draw on its extensive experience in optical systems and in the analysis and identification of suitable high-transparency glasses and thermoplastics for micro-optic components. Nanostructuring techniques, for instance, allow for the production of new materials for use in optics and photonics, such as photonic crystals and metamaterials. Fraunhofer IPM is also active in the development of new materials. In addition to work on nonlinear optical materials, it also develops and investigates thermoelectric, magnetocaloric and electrocaloric materials. Thermoelectric materials can generate electricity from heat. Magnetocaloric and electrocaloric materials, on the other hand, can be used to develop energy-efficient cooling systems that work without coolants

MATERIALS CHARACTERIZATION

To characterize thin films, Fraunhofer IST, Fraunhofer IWS and Fraunhofer FEP have a wide array of materials characterization techniques at their disposal, such as for chemical material analysis (spatially resolved, depth resolved, near-surface or averaged). These techniques include X-ray spectroscopy (EDX/WDX/EPMA), secondary ion mass spectroscopy (SIMS), photoelectron spectroscopy (XPS) and X-ray fluorescence analysis (RFA/XRF). Crystalline materials can also be examined using X-ray diffraction (XRD). Then there is also a range of application-specific testing techniques for characterizing material properties such as hardness, friction, wear, corrosion and fatigue behavior. For this, Fraunhofer IWS and Fraunhofer ILT have access to modern testing equipment used in metallography, light and electron microscopy, and microanalytics.

TRIBOLOGICAL SYSTEMS

One particular branch of the member institutes' research work is devoted to tribological coating systems and surfaces designed to increase wear resistance in highly loaded systems. This involves developing wear-resistant coatings as well as suitable post-machining and functionalization techniques that draw on the intrinsic properties of the respective material. In the field of tribological systems, Fraunhofer IST is working on the overall optimization of systems that are subject to wear or friction through the use of appropriate thin-film systems. Surfaces can be individually designed depending on the material, manufacturing history and operating conditions, and tested using impact testers or high-temperature or rolling tribometers.

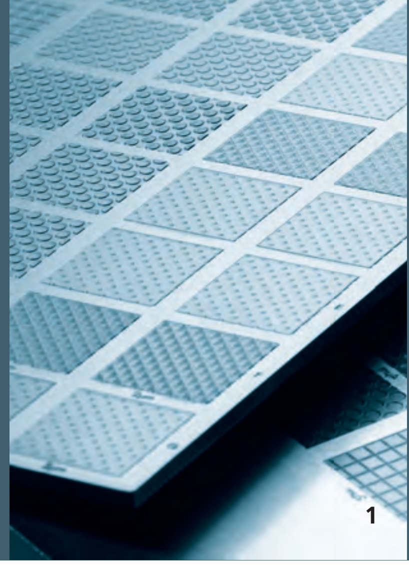
Fraunhofer ILT also has individual surface functionalization technologies at its disposal, such as heat treatment, coating and high-resolution microstructuring, all of which can improve wear resistance or reduce friction. Fraunhofer IWS has also developed its extremely wear-resistant and low-friction Diamor® coatings, which are made of tetrahedral amorphous carbon (ta-C). This makes them ideal as protective coatings for tools, parts and components that operate in lubricated and non-lubricated environments. In addition to this technology, Fraunhofer IWS also supplies the required coating sources and facilities, as well as its »LAwave« laser-acoustic test system for quality assurance and coat optimization.

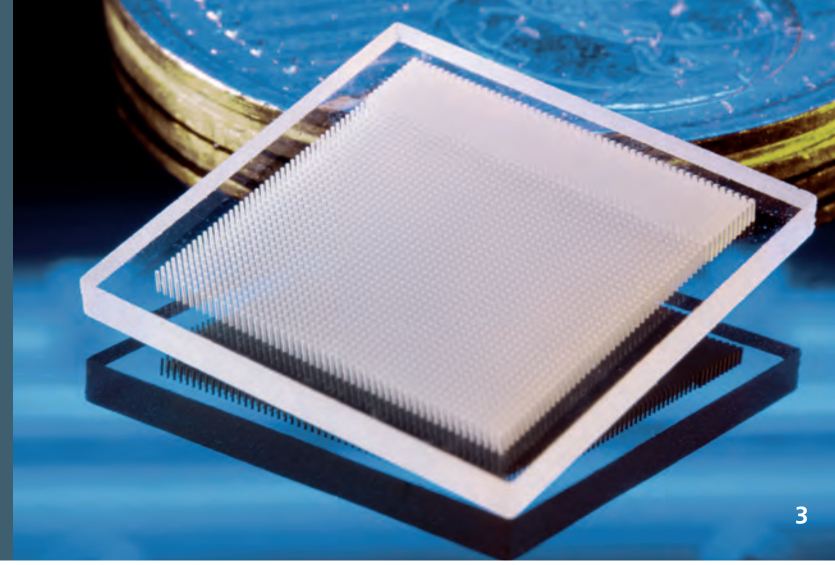
PROCESS-ADAPTED MATERIALS

Fraunhofer ILT develops innovative, functional acrylic, epoxy, and thiol-ene-based photopolymers that allow for selective light curing in the micrometer and submicrometer range. Materials are developed systematically with a close eye on the manufacturing processes used. This allows for the processing of various polymers using adapted laser beam sources (λ = 266 nm - 1 µm) or incoherent LED projections (spatial light modulation – SLM), and for the generation of high-resolution structures (2D or 3D) in line with the desired function of the product. The materials development process also takes particular properties into account, such as a material's mechanical, optical (high transparency and refractive power), electrical, chemical and biological (biocompatibility) properties.

1 Thermoelectric high-temperature modules.
2 DLC-coated segment of a tire mold.
2 Coating of transmission components using Diamor®-coatings.

MICRO- AND NANOTECHNOLOGIES





The member institutes possess a wide range of structuring methods and techniques for generating micro- and nanostructures. In addition to traditional lithographic techniques, they also use nanosecond, picosecond and femtosecond lasers for their microstructuring processes. As these processes are nearly athermal, they open up a wide range of applications across a variety of industrial sectors. Femto- and picosecond lasers offer unique properties, including evaporation-dominated material ablation and minimal heat input into workpieces, making it possible to create micro- and nanostructures on virtually any surface. The member institutes' extensive range of state-of-the-art equipment and in-depth understanding of the field enables them to conduct applied research into laser microprocessing and precision laser processing across the domains of mechanical and plant engineering, vehicle and equipment engineering, and biotechnology and medical devices.

Applications

- Microstructuring
- Nanostructuring
- In-volume modification
- Nanomaterials

1 Efficient manufacture of functional surfaces through the combination of nano- and picosecond pulses.

2 A laser-structured starry sky pattern on a watch dial.

3 Microstructures in glass created by Selective Laser Etching.

MICROSTRUCTURING

Fraunhofer ILT and Fraunhofer IOF develop ultrafast laser systems that achieve excellent beam quality coupled with rapid processing times. These systems are ideal for use in the high-precision structuring of a variety of materials, particularly metals, glasses, semiconductors and biological tissue. Fraunhofer IOF also uses photolithography, laser and electron beam lithography and reactive ion etching to produce and characterize functional surfaces and components, such as high-end, ultra-high-resolution micro- and nano-optical elements. Fraunhofer IST develops thin-film sensors that measure force and temperature in high-load environments; the sensors are applied directly to the tool or component and are structured using laser or optical lithography. Fraunhofer IPM manufactures sensors using bulk or hotplate technologies, etching structures of just a few micrometers in depth using RIE or ICP etching systems and wet chemical etching processes. Fraunhofer FEP has extensive experience in the processing of organic semiconductor materials, which are used to develop organic light-emitting diodes (OLEDs) and OLED microdisplays by means of coating and microstructuring with electron beam technology.

NANOSTRUCTURING

Functional surfaces often require structures that enhance the material's intrinsic properties or that are of a scale that creates a special physical or optical effect. This calls for reproducible nanostructures that can be rapidly generated using pulsed laser light.

The use of laser ablation techniques enables researchers to produce high-resolution surface structures, and a technique known as multibeam interference makes it possible to apply periodic structures in the 100 - 1000 nm range to components. Special optics allow a specific period and nanomode to be selected, which in turn, due to the interference occuring on the surfaces, enables certain interference colors to be applied to components and tools. Thanks to replication processes, these can be cost-effectively transferred to large-scale components. Furthermore, self-organization effects arising from ultrafast laser processing can be harnessed to enable nanostructuring in the 100 - 500 nm range. Here, functional structures are produced on metals and can then be transferred to metallic films and polymers using injection molding or embossing processes.

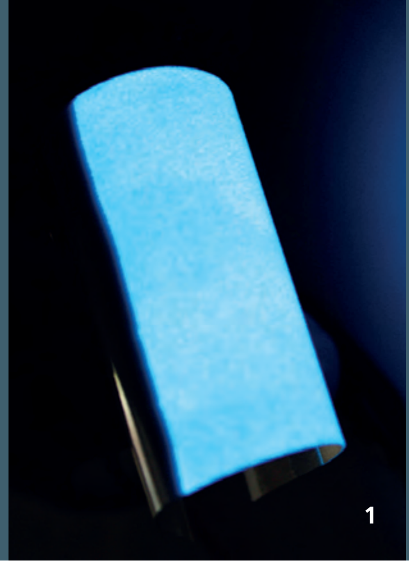
IN-VOLUME MODIFICATION

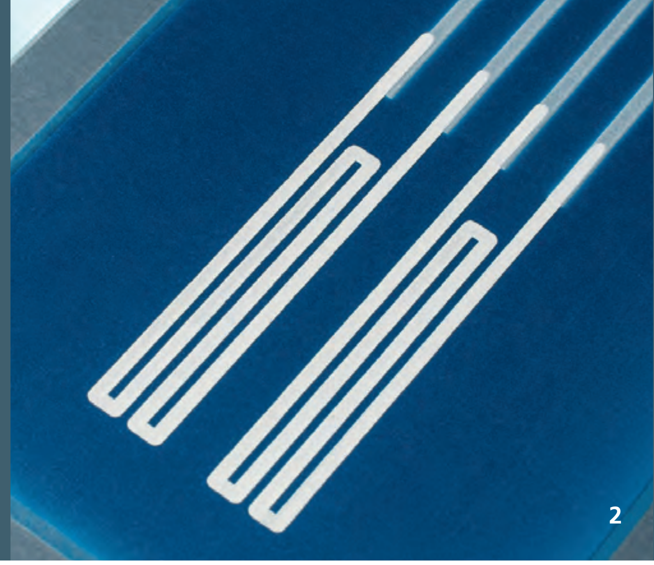
Using highly focused, ultrafast laser systems in the femto--second range, Fraunhofer ILT offers technology that can locally modify transparent materials such as glass, sapphire and other transparent ceramics. The multiphoton processes required for this are induced only at high intensities, so the material is altered only in the focal volume. Beam deflection with nanometer accuracy ensures that any 3D geometry can be built up layer by layer in the workpiece volume.

NANOMATERIALS

Fraunhofer IWS develops prototypes of reactors for surface treatment, including precision cleaning, functionalization and etching, and for the production of oxide and non-oxide coatings, nanoparticles, carbon nanotubes (CNT) and carbon fibers. It uses magnetron and ion beam sputter deposition to apply nanometer single- and multilayer coatings for EUV and X-ray optics. Techniques such as pulsed laser deposition are also used. In addition to developing and manufacturing precision coatings, Fraunhofer IWS has many years of experience in characterizing and modeling nanometer layers.

THIN-FILM TECHNOLOGY





Developing nanostructured materials that have a defined surface chemistry plays a critical role in optimizing surface properties – properties that are vital to a wide range of materials and substances once they are in use, such as scratch resistance. Researchers draw on a variety of coating treatments, including physical vapor deposition (PVD), sputter coating and chemical vapor deposition (CVD), as well as post-treatment processes, to produce a wide range of coatings and coating systems. These are used to provide functional coating, multimaterial coating systems for sensors, electronics and optics, and wear- and corrosion-protection coatings for tools and components. The member institutes have numerous processes, plants and clean rooms at their disposal, allowing them to combine wet-chemical coating treatments with laser processing techniques.

Applications

- PVD coating
- CVD and electrochemical coating
- Sputtering processes
- Coating design and thin-film modification

PVD COATING

The member institutes of the Fraunhofer Group for Light & Surfaces have a wide range of coating techniques at their disposal. PVD coating is one of the key technologies and is used by Fraunhofer IST and Fraunhofer FEP to manufacture a variety of coatings – for instance for components and small parts. This technique allows scientists to apply high-grade tribological and functional layers ranging in thickness from a few nanometers to a few micrometers. Fraunhofer IWS offers various processes for this purpose, from high-rate deposition to highly activated plasma processes and combinations of these.

CVD AND ELECTRO-CHEMICAL COATING

The member institutes also develop gas- and liquid-based coating processes designed for large-area coatings based on new materials. The focus here is on transparent, functional thin films and porous carbon layers for electrical energy storage. Fraunhofer IOF employs atomic layer deposition (ALD) to produce innovative, optimized optical nanostructures. Scientists also use high-vacuum evaporation systems with resistance and electron beam vaporizers or plasma ion sources for various coating applications, such as thermal evaporation of organic compounds.

Fraunhofer IST has a number of CVD techniques at its disposal, including the hot wire CVD process. For coating large areas using temperature-sensitive materials, the PECVD technique is an excellent choice. PECVD uses a plasma to deposit coatings in a gaseous state, allowing, for example, for the application of permeation-barrier coatings, optical layers or layer systems to plastic films. The layer properties can be varied relatively simply by adapting the plasma excitation and changing the composition of the process gas. PECVD coating is one of Fraunhofer FEP's core technologies, while Fraunhofer IST uses wet-chemical coating techniques such as atmospheric pressure in an aqueous environment for the deposition of metals.

SPUTTERING PROCESSES

Member institutes develop sputtering processes to efficiently apply layers and multilayer systems to large surfaces in a vacuum environment. The result is precision deposition of thin electrical and optical functional layers on an industrial scale. Fraunhofer IST employs magnetron sputtering and the hollow cathode technique for a wide range of coatings. At Fraunhofer IOF, magnetron sputtering is used on precision optics to meet increasing requirements for the quality and homogeneity of the coatings on large-scale optics. Conventional sputtering equipment is also used for the deposition of EUV/X-ray coating systems on substrates with diameters of up to 660 mm. Fraunhofer FEP specializes in pulsed magnetron sputtering (PMS) and regulating reactive sputtering processes. Oxides, nitrides and oxynitrides can be used alongside metals as deposition materials. In addition, the dual magnetron sputtering system (DMS) makes it possible to apply electrically highly insulating materials.

Fraunhofer IWS uses magnetron and ion beam sputter deposition as well as pulsed laser deposition to apply nanometer single- and multilayer coatings for EUV and X-ray optics.

COATING DESIGN AND THIN-FILM MODIFICATION

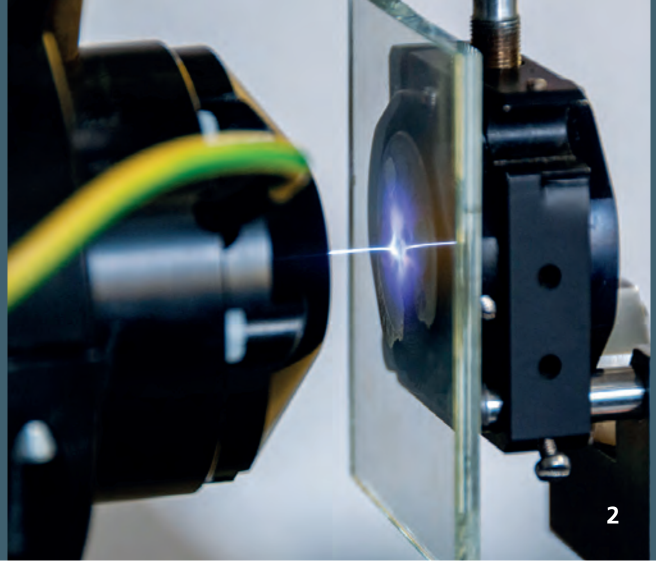
Thanks to its flexibility in both duration and location, the laser is the ideal tool with which to modify thin films by crystallizing, sintering or melting them. Particularly on thermally sensitive substrates such as glass, plastics and hardened steels, the low thermal load of laser radiation on the substrate as compared with conventional processes can often be the key to producing functional layers. Furthermore, localized treatment of layers opens up new possibilities in the design of surface properties, such as functional and multimaterial coating systems, tribological layers and nano- and microparticulate layers.

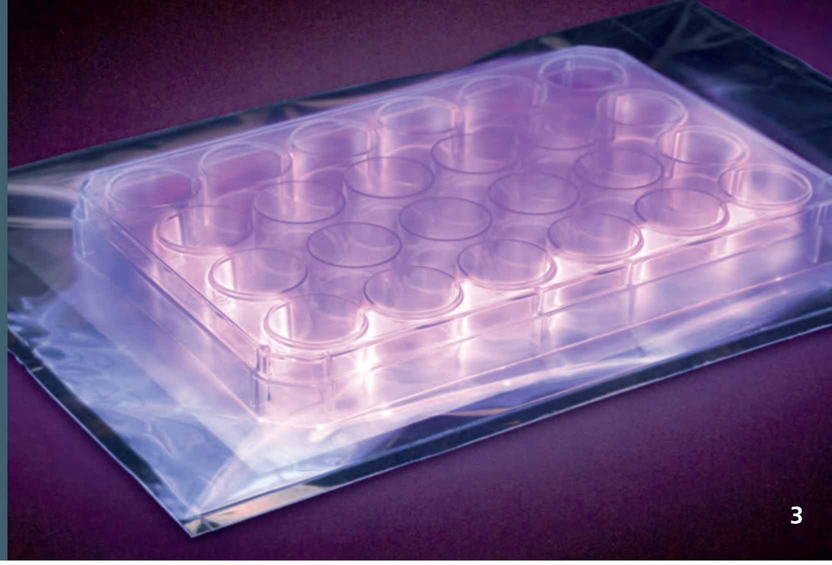
1 Electroluminescent film as a transparent electrode.

2 Detailed view of a sensor structure.

3 Hydrophilic, hydrophobic structured surface.

PLASMA TECHNOLOGY





Plasma technology is an important tool in the production, modification and functionalization of coatings and surfaces. The member institutes of the Fraunhofer Group for Light & Surfaces use this technology to produce special layer functions and to modify laser-produced layers. By applying excitation techniques in the gas phase, they are able to selectively modify layer compositions and surface conditions and adapt them to the respective application, for example for cleaning surfaces or activating polymer films, wood and wood composites. Coating processes performed under atmospheric pressure employ additional plasma processes to regulate wettability and surface tension. These can be selectively adjusted to create hydrophilic, hydrophobic and even super-hydrophobic surfaces. Plasma processes are also used for medical applications and to alter material properties. Here, the high electron energy of the plasmas and the resulting UV radiation are used to activate or deactivate surfaces.

Applications

- Plasma sources
- Atmospheric pressure plasma processes
- Plasma processes

PLASMA SOURCES

Plasma activation during vaporization boosts particle energy, allowing for efficient coating over large areas and impacting positively on bond formation. It requires powerful sources that are adapted for both high coating speed and large-area coating. Fraunhofer FEP develops processes tailored to this application by combining high-rate deposition with differently guided arc discharges (SAD and HAD process). Fraunhofer IWS develops large-scale atmospheric pressure plasma processes sources tailored to customers' specific applications. The »LARGE« plasma source of the institute in Dresden is notable for its use of a large number of process gases, as well as a compact design that makes it easy to integrate into inline or robot-controlled processes. The »Disk-Jet« plasma source developed at Fraunhofer IST operates on the principle of dielectric barrier surface discharge, enabling treatment of temperature-sensitive substrates over large areas while ensuring contour accuracy and depth.

ATMOSPHERIC PRESSURE PLASMA PROCESSES

Atmospheric pressure plasma processes are used in industry to activate and clean surfaces. Here, Fraunhofer IST develops new, customer-oriented techniques and plasma sources that make it possible to modify or coat different surfaces on 3D substrates. Areas of application include microsystems technology, medical devices, the packaging and electronic goods industry, and the automotive and aerospace industries. By employing suitable gases and reagents, atmospheric pressure plasmas can also be used to chemically functionalize surfaces using reactive groups, and thus optimize adhesion. Furthermore, the institute develops methods that use microplasmas to enable targeted local modification of surfaces on a scale of less than 10 µm; this can be used, for example, to adjust the desired surface energy. Fraunhofer IWS also develops plasma-assisted processes at atmospheric pressure to enable cleaning, activation and etching of large-area surfaces. With these, high-grade functional layers can be applied without the use of expensive vacuum equipment, making it feasible to run continuous coating processes on temperature-sensitive materials as well as on slightly curved substrates of different thicknesses.

PLASMA PROCESSES

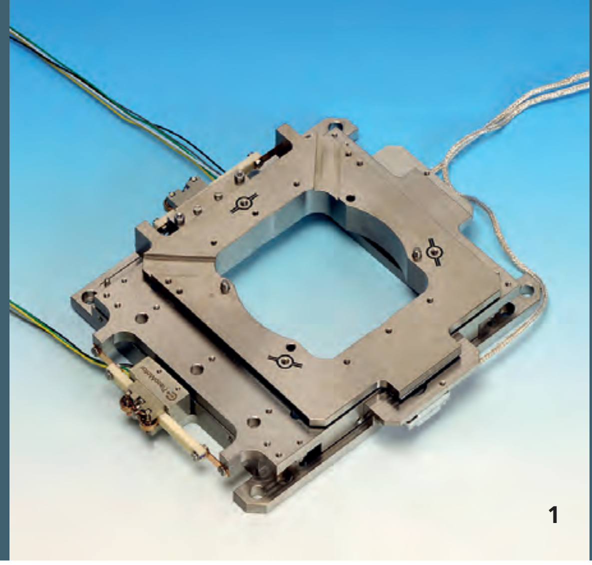
Atmospheric pressure plasma processes are commonly used in the industry to clean surfaces and to activate polymer films, wood and wood composites to improve their wettability. Fraunhofer IST continuously refines technologies that allow for targeted insertion of functional groups through suitable process control. As a result, the adhesion of lacquers and adhesives is significantly improved, as the surface is adapted to the reactive layer system. In this way, atmospheric plasma processes can be used to produce barrier coatings on flexible substrates, for example to prevent PVC plasticizers from migrating. These processes can be used to coat not just plastic films and glass substrates, but also textiles, porous substrates and objects with 3D geometries. Plasma-activated high-rate deposition and plasma-enhanced chemical vapor deposition (PECVD), an established technique for applying silicon-based coatings for a variety of applications, are both core technologies at Fraunhofer FEP.

1 »Disk-Jet – DBD« dielectric barrier surface-discharge plasma source.

2 A direct, dielectrically impeded plasma beam discharged onto glass.

3 Atmospheric pressure plasma treatment of a microtiter plate.

ELECTRON BEAM TECHNOLOGY



Electron beam technology is particularly suited to high coating rates and, because it requires a vacuum, is the ideal tool for large-area film coating processes. The member institutes of the Fraunhofer Group for Light & Surfaces dedicate themselves to the development of technologies and processes for surface refinement and for organic electronics. Electron beam technology is used to solve a variety of industrial surface engineering problems. The group institutes have numerous industrial plants at their disposal for coating large surfaces in batch systems, in-line or in roll-to-roll processes, and electron-beam systems for the efficient treatment of surfaces. For specific applications in organic electronics, Fraunhofer FEP also has several clean rooms with research and development lines. These facilities enable the institute to refine and coat flat substrates made of glass, plastic or metal; flexible surfaces such as metallic strips, flexible glass and plastic films; and even three-dimensional components and silicon wafers.

Applications

- Electron beam sources
- Electron beam coating
- Electron beam lithography
- Materials modification

ELECTRON BEAM SOURCES

Fraunhofer FEP develops electron beam sources for a range of applications and requirements, from developing technology and processes to providing complete package solutions. In addition to technology transfer and process commissioning in production, Fraunhofer FEP also offers the following services: equipping systems with key components (as well as retrofitting existing systems); scaling processes and technologies for industrial facilities; creating complete package solutions including beam control, arc protection circuitry, and power, beam and sweep generators; adapting electron beam sources to specific customer requirements; developing special solutions; and providing and integrating optional additional components.

ELECTRON BEAM COATING

Fraunhofer FEP develops technologies and processes for surface refinement and organic electronics. The institute employs core technologies such as sputtering, high-rate PECVD and electron beam technology to solve diverse industrial problems in surface engineering. Alongside materials such as glass, plastic and metal, ultra-thin glass, also known as flexible glass, is a relatively new material that is being considered as a substrate, with its excellent surface properties and low substrate roughness. The institute is investigating both sheet-to-sheet and roll-to-roll deposition processes to enable the use of ultra-thin glass in high-tech devices.

ELECTRON BEAM LITHOGRAPHY

Thanks to its small spot sizes of just a few nanometers, electron beam lithography is an ideal tool for use in nanotechnology. Fraunhofer IOF has many years of expertise in generating sophisticated optical micro- and nanostructures. The key technology it uses for this is electron beam lithography. The institute's technological equipment enables it to efficiently generate optical micro- and nanostructures on surfaces up to 300 mm in size with the highest precision and resolution.

MATERIALS MODIFICATION

Quite aside from the generally high spatial resolution electron-beam processing facilitates, the high energy and particulate nature of this technique opens up further possibilities in materials processing. Fraunhofer FEP uses electron beams to achieve controlled chemical and biological effects on material surfaces. In the case of seed dressing – a well-established market method – low-energy accelerated electrons are used to destroy the DNA of harmful pests. Low-energy accelerated electrons can also be used to sterilize and disinfect surfaces of medical products (implants, devices), packaging, and food and animal feed.

The technology is non-destructive and environmentally friendly, enabling even sensitive materials and products to be disinfected and sterilized within seconds to milliseconds. The samples can be processed under atmospheric pressure and retain their dimensional stability as well as their product-specific properties. The electron beam can also sterilize the product surface through any packaging, which simplifies sterilization processes considerably. During the coating process, non-thermal electron beam technology is used to apply surface morphological and energy characteristics that counteract bacterial adhesion, preventing germs from accumulating on the surface in the first place.

Aside from this, electron beam modification of plastics serves primarily to improve surface adhesion. In the printing industry in particular, electron beam treatment is of critical importance in achieving optimum adhesion when applying inks, compounding polymer granules or applying barrier coatings for any number of applications on plastic films.

1 A precision positioning system for electron beam applications.

2 A testing facility for 3D coating using pulsed magnetron sputtering.

3 Glass with anti-reflection coating.

Contact

Prof. Reinhart Poprawe (Chairman)
Steinbachstraße 15
52074 Aachen, Germany
reinhart.poprawe@ilt.fraunhofer.de

Dr. Arnold Gillner (Managing Director)
Steinbachstraße 15
52074 Aachen, Germany
arnold.gillner@ilt.fraunhofer.de

www.light-and-surfaces.fraunhofer.de/en

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 72 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 25,000, who work with an annual research budget totaling 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

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