Fraunhofer
IST

FRAUNHOFER INSTITUTE FOR SURFACE ENGINEERING AND THIN FILMS IST

ANNUAL REPORT 2019

COVER *Electrodes for battery cell production.*

FOREWORD

1 *Director Prof. Dr. Günter Bräuer (left) and director Prof. Dr. Christoph Herrmann (right).*

Ladies and gentlemen,

the year 2019 was a very successful year for the Fraunhofer Institute for Surface Engineering and Thin Films IST in many ways with various innovative developments. We provide you with a selection of the most important events and latest research developments of the Fraunhofer IST in the annual report at hand.

We would like to take this opportunity to express our thanks to all people whose hard work and commitment made our success possible in the first place: above all the employees of the Fraunhofer IST, our partners from research and development, our customers from industry, our sponsors, colleagues and friends. Thank you for a trusting cooperation.

Dear reader, we hope you enjoy reading our annual report and are looking forward to your ideas for cooperation in future.

Prof. Dr. Günter Bräuer

Prof. Dr. Christoph Herrmann

TABLE OF CONTENT

1


2

2019 IN RETROSPECT

"#WHATSNEXT" – Under this motto, the Fraunhofer-Gesellschaft celebrated its seventieth anniversary in 2019.

"#WHATSNEXT" – This is the question which we also have to ask ourselves, shortly before the completion of this activity report in March 2020. This "#WHATSNEXT" has, however, a significance of a completely new dimension. The world has come to a standstill and we ponder, with concern, over how life will be following the end of the COVID-19 pandemic.

But let us look back at March 26, 2019, when we celebrated the 70th birthday of our Gesellschaft in the form of a small ceremonial event with the employees of the Fraunhofer IST. During a short presentation on "The quantum leap and the missing colors of the sun", we first honored the merits of our eponym, Joseph von Fraunhofer, and then subsequently consumed a huge marzipan cake decorated with the famous Fraunhofer spectrum.

Our graduates of the physics laboratory assistant training course also had a reason to celebrate this year. Both trainees completed their final exams with particular success. One of them is among the best of the chamber and the Fraunhofer-Gesellschaft. We are proud, not only of our trainees but also of the quality of our training, which was also honored.

Furthermore, there were a number of other highlights in 2019. For two events, magnetron sputtering formed the technological focal point: In mid-June, around 100 participants and 20 industrial exhibitors came together in the Stadthalle in Braunschweig for the International Conference on High Power Impulse Magnetron Sputtering, where they exchanged scientific information on the latest results in the field of highly ionized plasmas. The annual conference is presented in collaboration with the Sheffield Hallam University in Great Britain, and in the odd-numbered years it is organized by the network INPLAS in Braunschweig, which operates under the roof of the Fraunhofer IST. It documents our close cooperation as well as the intensive exchange of students.

The fact that the Fraunhofer IST was also entrusted with the organization of the "18th International Conference on Reactive Sputter Deposition RSD" once again underlines the international recognition of our work in the field of sputtering technologies. The RSD has its roots in Belgium, where various universities have built up a high level of competence in the field of sputter process research over the past few decades. At the beginning of December, around 100 scientists from 22 countries, together with 10 exhibitors, met at the 18th RSD on the premises of the Fraunhofer IST. In this regard, special thanks are due to the City of Braunschweig for making available to us the Dornse, the banqueting hall of the Old Town Hall, thereby providing the conference dinner with a festive setting.

With the new institute management, the networking between the Technische Universität Braunschweig and the Fraunhofer IST is being perceptibly strengthened. At the end of June, the institute participated for the first time in the TU Night – a mixture of science festival and campus open-air. The IST is now also anchored in all the relevant centers of the TU, such as the Open Hybrid LabFactory and the Battery LabFactory Braunschweig. With the kick-off event for the Fraunhofer Project Center for Energy Storage and Management Systems ZESS, which was attended by the president of the Fraunhofer-Gesellschaft, the prime minister of Lower Saxony and the president of the TU Braunschweig, a further important milestone for the future work of the IST was set.

On the following pages, information is available concerning the diverse results of our day-to-day research work. We must, however, remain silent regarding additional interesting results, as these were achieved in direct cooperation with industrial partners and are therefore subject to confidentiality.

Yours,
Günter Bräuer

1 *Sugary-sweet future prospects on the Fraunhofer-Gesellschaft's 70th birthday.*

2 *Celebratory event for the kick-off of the ZESS.*

3 *The institute presents itself with a stand at the TU Night.*

BOARD OF TRUSTEES

FROM THE BOARD OF TRUSTEES

Constantly increasing capacity utilization of medical staff in standard care and a lack of funds for countering the investment backlog – these are issues that cause concern for hospitals and pose major challenges for their future. In Braunschweig, we are already breaking new ground, critically examining the procedures and working processes in the clinic and developing innovative solutions in collaboration with partners such as the Fraunhofer IST. The spatial proximity as well as the short communication channels make it possible to quickly formulate and implement ideas from both sides. One current example is the realization of a model hospital room at the Fraunhofer institute in order to gain an understanding of our problems.

The cooperation began with the coating of cell culture bags in order to optimize the growth conditions of human dendritic cells and stem cells. This gave rise to a project which offers a cost-effective possibility for carrying out 3-dimensional cell cultivation within a closed system (Labbag®). This technique, developed by the Fraunhofer IST, is important for the further development of personalized medicine in hospitals and enables the cultivation of organoids and tumor organoids.

Innovative solutions are, however, also being used to address everyday hospital problems in completely different areas. One example is the bed sensor, which makes it possible to accurately weigh critically ill intensive-care patients without having to place them on a scale. This results in huge time savings and the possibility of a better (more patient-oriented) application of drugs such as antibiotics. The bed sensor was created by modifying techniques developed at the Fraunhofer IST for a completely different purpose.

A further topic concerns the antibiotic and cytostatic drug residues from hospitals in wastewater. Here, too, the expertise of the Fraunhofer IST provides possibilities for neutralizing the wastewater, thereby contributing towards our hospital becoming a green hospital. The ongoing development of a barrier layer for plasticizers such as DEHP enables the production of medical products which release plasticizers into the environment in smaller quantities and more slowly – a new approach that can achieve a major impact in hospitals.

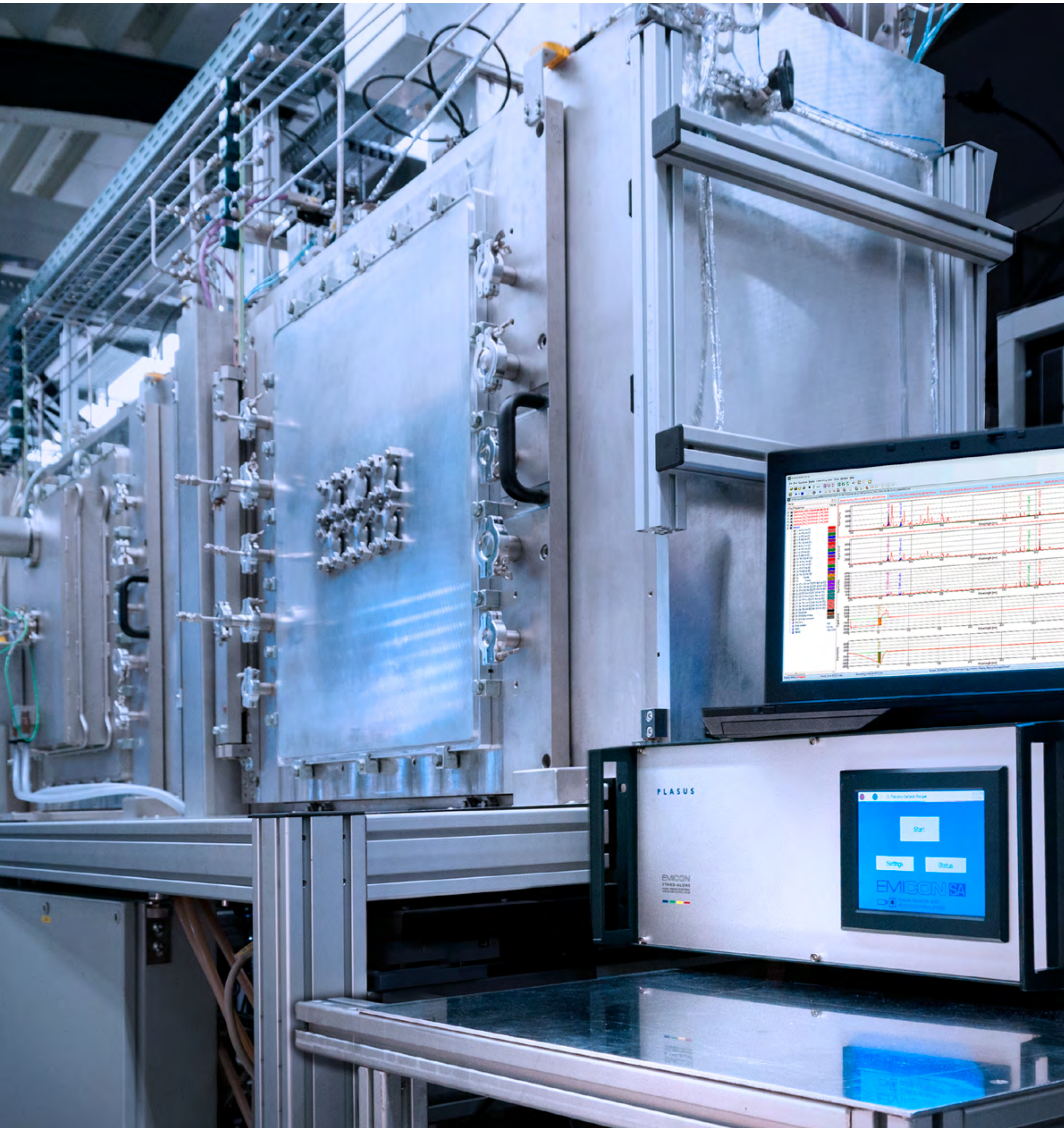
Close cooperation between research institutes, such as the Fraunhofer IST, and clinical users is a win-win situation and enables all participants to realize demand-oriented product or process innovations in medical technology.

The cooperation between the Städtisches Klinikum Braunschweig and the Fraunhofer IST is also particularly valuable in view of the possible establishment of the campus for the Universitätsmedizin Göttingen at the Städtisches Klinikum Braunschweig, which would provide future medical training, thereby bringing together research and teaching.

I am extremely pleased with the existing cooperation and wish all Fraunhofer employees and the institute management every success for the year 2020.

Dr. Thomas Bartkiewicz
Städtisches Klinikum Braunschweig gGmbH

OUTSTANDING COLLABORATION

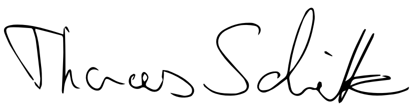


Technological progress through scientific and entrepreneurial success in plasma and surface technology is, in many cases, founded on a constructive, transparent and goal-oriented cooperation of partners with differing expertise. Such an excellent cooperation between Fraunhofer IST and PLASUS GmbH has resulted in successful projects, publications and products in recent years.

PLASUS GmbH, located in Mering near Augsburg, is a worldwide leading manufacturer of spectroscopic plasma monitor and process control systems for all types of plasma processes in R&D and industry. Founded in 1996, PLASUS develops, produces and distributes innovative and application oriented systems for plasma monitoring and process control. Applications range from quality control of PECVD plasmas, through active process control in reactive sputtering processes and endpoint detection in etching processes, and to the process monitoring of atmospheric plasmas.

Pioneering control techniques for highly ionized plasmas have resulted from the long-standing cooperation between Fraunhofer IST and PLASUS GmbH in various projects. Especially for pulsed highly ionized reactive plasmas, such as HIPIMS, a new control concept was designed at Fraunhofer IST and implemented by PLASUS GmbH in its process control systems EMICON for production lines. For the first time, the stoichiometry and the ion density in these plasmas can now be adjusted and controlled independently, which enables reproducible layer depositions in production processes. The Fraunhofer IST has always paid special attention transferring results to industrial environments – a crucial aspect for successful commercialization. A further focus of the cooperation with the Fraunhofer IST was the analysis and process development of atmospheric plasmas for the cleaning and coating of surfaces. Detailed investigations and collaborative analyses with the plasma monitor systems of PLASUS GmbH have resulted in innovative scientific findings and applications in the field of print technologies and medical technology.
In continuation of these successful projects, the potential of spectroscopic plasma monitoring for plasma diffusion processes will be investigated in the future.

Every collaboration with the Fraunhofer IST had in common the goal-oriented development with regard to an industrial implementation. I would like to express my gratitude and appreciation for this excellent cooperation, which was always consequent, consistently strong and frank, and pleasant at any times.



Dr.-Ing. Thomas Schütte
PLASUS GmbH

INSTITUTE PROFILE

Surfaces and films for sustainable products and related production systems are the center of the Fraunhofer Institute for Surface Engineering and Thin Films IST. As an internationally recognized partner in applied research, the institute taps the synergies of process engineering and production technology. Based on the mission statement of sustainability, around 120 employees create systems from the material through the process to the component, from the process chain to the factory, to recycling.

Current priorities in the business units mechanical engineering, tools and automotive technology, aerospace, energy and electronics, optics and life science and ecology are:

- Cyber-physical systems / Computational surface engineering & science
- Smart surfaces
- Sensor technology / Industry 4.0
- Energy storage systems
- Multifunctional surfaces
- Precision optical coatings

The employees work together with customers from industry and research to develop customized solutions: from prototypes through economic production scenarios to upscaling to industrial magnitudes – and all this whilst maintaining closed material and substance cycles. In addition to application-oriented research and development, scientific principles are also researched within various collaborations with universities and research institutions.

Coating and surface technology is the key to innovative products and systems: Through modification, patterning and coating of the surface, a wide range of functions and functionalities can be realized. Friction reduction, abrasion and corrosion protection, sensor features or optical properties are just a few examples.

For this purpose the Fraunhofer IST offers these available technologies among others:

- Electrochemical processes, in particular electroplating,
- atmospheric pressure processes,
- low-pressure plasma processes with the main focus on magnetron sputtering, highly ionized plasmas and plasma-activated vapor deposition (PECVD),
- chemical vapor deposition with the main focus on hot-wire CVD as well as
- atomic layer deposition (ALD).

One of the institute's particular strengths is its ability to create the optimum process chain for the respective task on the basis of a broad spectrum of processes and coating materials.

The Fraunhofer IST not only has excellent capabilities in surface analysis using the very latest equipment but has also accumulated extensive experience in the modeling and simulation of both product properties and the associated processes and production systems.

At the site in Braunschweig the institute has an office and laboratory area of more than 4000 square meters. In addition, the new building of the Application Center for Plasma and Photonics provides 1500 square meters of office and laboratory area in Göttingen.

Since its opening on February 7, 2019, the Fraunhofer IST, in collaboration with the Fraunhofer Institutes for Ceramic Technologies and Systems IKTS and for Manufacturing Technology and Advanced Materials IFAM, participate in the Project Center for Energy Storage and Management Systems ZESS. For the end of 2023, it is planned to move into a new research building holding up to 100 employees at the Research Airport Braunschweig. During the transition phase, laboratory space at the Niedersächsisches Forschungszentrum Fahrzeugtechnik (Lower Saxony research center for vehicle technology, NFF) and offices in the Lilienthalhaus at the Research Airport Braunschweig will be rented.

The range of services offered by the Fraunhofer IST is complemented by the expertise of other institutes within the Fraunhofer Group "Light & Surfaces" as well as by the competencies of the Institutes for Surface Technology IOT and for Machine Tools and Production Technology IWF of the TU Braunschweig, which are simultaneously led by the managers of the IST Prof. Günter Bräuer and Prof. Christoph Herrmann.

THE INSTITUTE IN FIGURES

Employee development

In the reporting period, the Fraunhofer Institute for Surface Engineering and Thin Films IST employed around 111 members of staff. Fifty percent of the employees thereby belong to the proportion comprising scientific staff, doctoral students and engineers. Technical and business staff as well as a multitude of diploma students and student assistants support the research work. The services of the Administration and Technical Services departments are provided by these employees for both the Fraunhofer IST and the Fraunhofer WKI, which is also located on campus. In 2019, the offer for training in the professional branches of electroplating, physics and specialized information technology was utilized.

Operating budget

In 2019, the operating budget lay at 12.7 million euros. The personnel costs amounted to 8.2 million euros. An outlay of 4.5 million euros was incurred for internal cost allocations and material expenses.

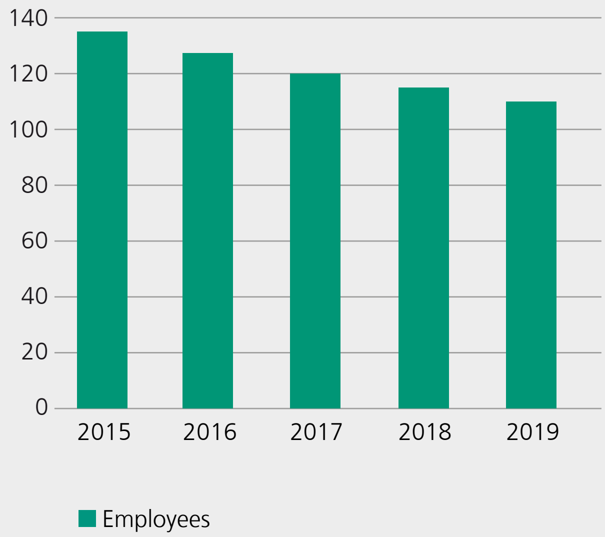
Revenue structure

Industrial revenues amounted to 4.5 million euros and public funding to 2.6 million euros. In total, external revenues of 7.1 million euros were therefore achieved.

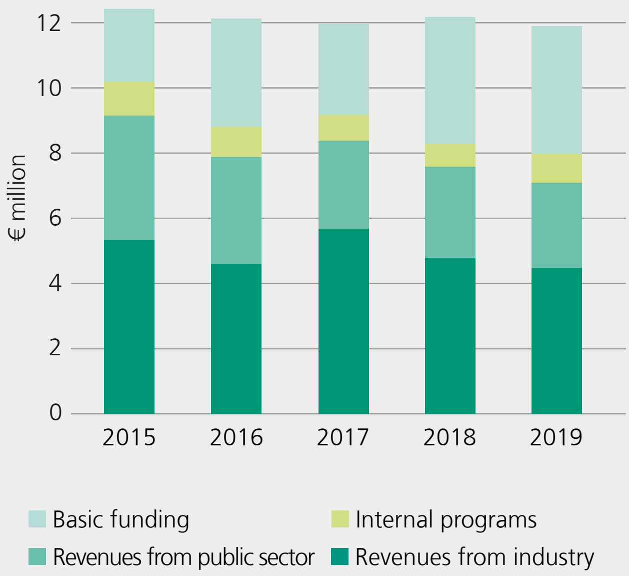
Investment budget

The Fraunhofer Institute for Surface Engineering and Thin Films undertook investments totaling 1.4 million euros. Around € 50,000 were invested here through external project funds, whilst € 612,000 were realized through normal investments. In 2019, € 593,000 were spent on strategic investments and € 134,000 on special allocations.

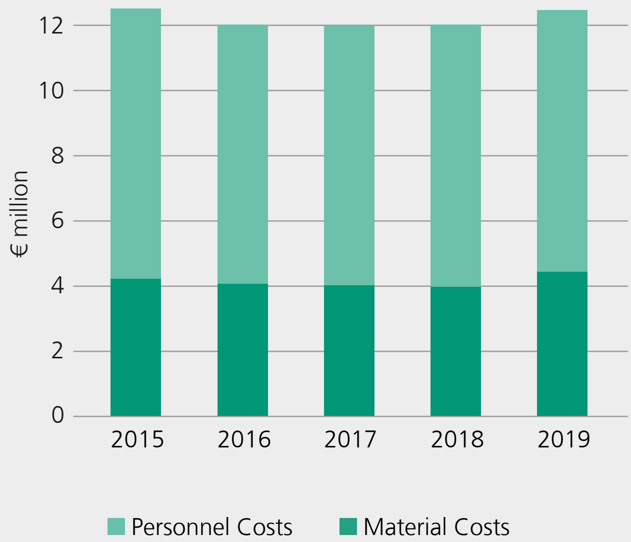
Employee development



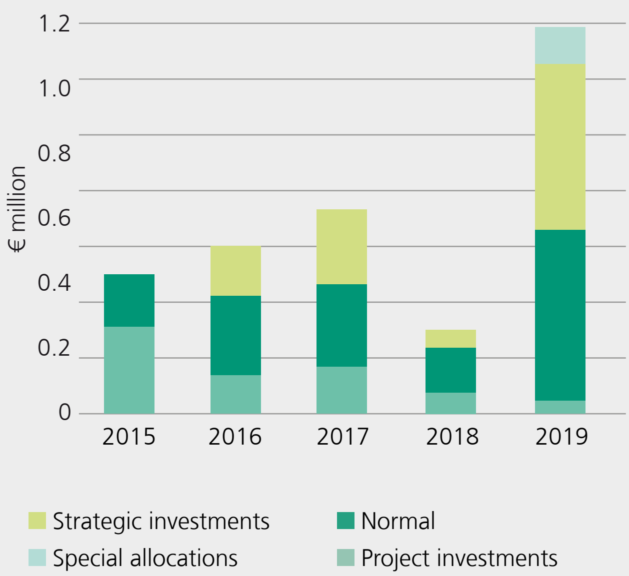
Revenue structure



Operating budget



Investment budget



1

ZESS – CENTER FOR ENERGY STORAGE AND SYSTEMS

On February 7th, the starting signal was given for the new Fraunhofer Project Center for Energy Storage and Systems ZESS in Braunschweig, which the Fraunhofer-Gesellschaft will operate in close cooperation with the Technische Universität Braunschweig. In addition to the Fraunhofer IST, the partners involved are the Fraunhofer Institute for Ceramic Technologies and Systems IKTS and the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM. The aim of the project center is to develop novel mobile and stationary energy storage systems to the level of industrial maturity. The future of numerous sectors of industry and technology hinges, directly or indirectly, on the development of new energy storage systems: electric cars need powerful batteries, and stationary power storage systems can stabilize electrical grids which are fed by temporally fluctuating renewable energy sources such as photovoltaic systems or wind turbines. This is where the Fraunhofer Project Center ZESS comes into its own, providing innovative contributions to social and ecological challenges and presenting efficient, climate-friendly solutions.

Ambitious goals – the new ZESS research building

For the five-year launch phase, the Fraunhofer-Gesellschaft and the State of Lower Saxony are contributing a total of 20 million euros in start-up funding in order to promote the competence development and networking of the participants in Lower Saxony within the framework of 20 individual projects. Furthermore, 40 million euros have been earmarked for the construction of a new research building for up to 100 employees at the Research Airport Braunschweig. The HDR architectural office has been commissioned to plan the new building, which is scheduled to be occupied by the end of 2023. Accordingly, the stakeholders from the three institutes involved are driving the planning onwards in leaps and bounds. Amongst other things, the requirements concerning the technical infrastructure and occupational safety must currently be defined within the framework of the building and interior design. Under the leadership of the Fraunhofer headquarters, the necessary construction work is to be put out to tender at the beginning of 2020. Subsequently, the specific planning of the plant technology for a pilot line for the production of next-generation lithium batteries, so-called solid-state batteries, can begin. Until the employees are able to move into the new building, offices are available for them in the "Lilienthalhaus" at the research airport in addition to a technical center on the premises of the neighboring Automotive Research Centre Niedersachsen (NFF). The first test cells for solid-state batteries are to be produced there on a pilot scale as early as 2020.

Focus of the Fraunhofer IST: Process and manufacturing technology for energy storage systems

Within the framework of the founding of the ZESS, the new department "Process Technology and Production Engineering" was established at the Fraunhofer IST; the department has been headed by Sabrina Zellmer since 1st July 2019. The activities of the department encompass the entire life cycle of

energy storage devices – from material production through the various production stages to use and subsequent recycling. The working group "Energy Storage Development and Production Engineering" headed by Jutta Hesselbach, thereby focuses on the production and functionalization of innovative battery materials, such as solid electrolytes and lithium metal anodes. The traditional core competencies of the Fraunhofer IST, such as the application of protective layers or the manufacture of ultra-thin metal films, are of essential importance in this context. A major challenge is posed by the scaling-up of the associated production processes from laboratory to pilot scale. The working group "Sustainable Factory Systems and Life Cycle Management", headed by Stefan Blume, addresses the holistic design of the production system for energy storage devices. Diverse and complex interactions between product, processes, technical building equipment and buildings are thereby taken into account. The focus is directed in particular at methods of the "digital factory", such as the simulation and construction of "digital twins" of products and processes. Furthermore the working group extends the scope to cover the entire product life cycle. Using methods such as "Life Cycle Assessment" and "Life Cycle Costing", technical-economic-ecological analyses of the life cycle of energy storage devices and systems are carried out. The security of supply as well as social aspects, such as working conditions during the extraction of the required raw materials, are also taken into account. As a result, the advantages and disadvantages of new technologies can be identified and quantified as early as during the development phase and can be used to support strategic decisions in favor of sustainable technologies.

1 *Planned new building for the ZESS.*

2 *At the launch of the Fraunhofer Project Center for Energy Storage and Systems ZESS in Braunschweig: Prof. Arno Kwade, Institute Director of the iPAT at the TU Braunschweig; Prof. Christoph Herrmann, Institute Director of the Fraunhofer IST; Prof. Heinz Jörg Fuhrmann, Chairman of the Senate of the Fraunhofer-Gesellschaft; Reimund Neugebauer, President of the Fraunhofer-Gesellschaft; Prof. Anke Kaysser-Pyzalla, President of the TU Braunschweig; Stephan Weil, Minister President of the State of Lower Saxony; Ulrich Markurth, Lord Mayor of the City of Braunschweig; Prof. Michael Stelter, Deputy Institute Director of the Fraunhofer IKTS; Prof. Alexander Michaelis, Institute Director of the Fraunhofer IKTS; Prof. Matthias Busse, Institute Director of the Fraunhofer IFAM (f.l.t.r.).*

CONTACT

Dipl.-Ing. Sabrina Zellmer
Phone +49 531 2155-528
sabrina.zellmer@ist.fraunhofer.de

Stefan Blume, M. Sc.
Phone +49 531 2155-532
stefan.blume@ist.fraunhofer.de

YOUR CONTACT PERSON

INSTITUTE MANAGEMENT AND ADMINISTRATION

Institute management

Prof. Dr.-Ing. Christoph Herrmann[1]
Phone: +49 531 2155-503
christoph.herrmann@ist.fraunhofer.de

Prof. Dr. Günter Bräuer[2]
Extension: 500
guenter.braeuer@ist.fraunhofer.de

Research strategy and coordination
Deputy director

Dr. Lothar Schäfer[3]
Extension: 520
lothar.schaefer@ist.fraunhofer.de

Research planning and networks
Assistant head of Institute

Dipl.-Ing. Carola Brand[4]
Extension: 574
carola.brand@ist.fraunhofer.de

Process and innovation management

Dr. Marko Eichler[5]
Extension: 636
marko.eichler@ist.fraunhofer.de

Administration

Ulrike Holzhauer[6]
Extension: 220
ulrike.holzhauer@ist.fraunhofer.de

Marketing and communications

Dr. Simone Kondruweit[7]
Extension: 535
simone.kondruweit@ist.fraunhofer.de

IT

Andreas Schlechtweg[8]
Extension: 633
andreas.schlechtweg@ist.fraunhofer.de

Technical services

Stephan Thiele[9]
Extension: 440
stephan.thiele@ist.fraunhofer.de

HEADS OF DEPARTMENT, GROUP MANAGERS AND TEAM MANAGERS

Low pressure plasma processes

Dr. Michael Vergöhl[10]
Extension: 640
michael.vergoehl@ist.fraunhofer.de
Optical coating systems | Process engineering | Materials engineering

Magnetron sputtering

Large area electronics | Transparent and conductive coatings | Asset and process development | New semiconductor for photovoltaic and microelectronics

Highly ionized plasmas and PECVD

Dr.-Ing. Ralf Bandorf[11]
Extension: 602
ralf.bandorf@ist.fraunhofer.de
Multifunctional coatings with sensors | High Power Impulse Magnetron Sputtering (HPIMS) | Micro tribology | Electrical coatings | Hollow cathode processes (HKV, GFS) | Plasma-enhanced CVD (PECVD)

Simulation

Dr. Andreas Pflug[12]
Extension: 629
andreas.pflug@ist.fraunhofer.de
Simulation of plants, processes and coating layer properties | Model-based interpretation of coating processes

Chemical vapor deposition

Dr. Volker Sittinger[13]
Extension: 512
volker.sittinger@ist.fraunhofer.de

Dr. Markus Höfer[14]
Senior Scientist
Extension: 620
markus.hoefer@ist.fraunhofer.de

Atomic layer deposition

Dipl.-Chem. Tobias Graumann[15]
Extension: 647
tobias.graumann@ist.fraunhofer.de
Product-related system construction | Coating and process development | Highly compliant coatings of 3D structures

Hot-wire CVD

Dr.-Ing. Christian Stein[16]
Extension: 647
christian.stein@ist.fraunhofer.de
Diamond coatings and silicon-based coatings | Tool and component coatings for extreme wear resistance | Diamond coated ceramics DiaCer® | Electrical applications for semiconductors, barriers | Antireflective

Photo and electrochemical environmental engineering

Frank Neumann[17]
Extension: 658
frank.neumann@ist.fraunhofer.de
Test engineering | Photocatalysis | Diamond electrodes for electrochemical water treatment | Air, water and self-cleaning | Product evaluation and efficiency determination

Atmospheric pressure processes

Dr. Michael Thomas[18]
Extension: 525
michael.thomas@ist.fraunhofer.de

Atmospheric pressure plasma processes

Dr. Kristina Lachmann[19]
Extension: 683
kristina.lachmann@ist.fraunhofer.de
Surface functionalization and coating | Small volume production | Plasma printing | Microplasmas | Low temperature bonding | Electrode development and plant engineering | Adhesive layers and anti-adhesive coatings

Electrochemical processes

Rowena Duckstein, M. Sc.[20]
Extension: 619
rowena.duckstein@ist.fraunhofer.de
Process development | Metal coatings | Plastics metallization | Ionic fluids | Plastic and metal pretreatment | Electrochemical synthesis

Surface chemistry

Dr. Kristina Lachmann[19]
Extension: 683
kristina.lachmann@ist.fraunhofer.de
Biofunctional coatings | Layer-by-layer-processes | Vapor deposition and photopolymerization | Detection of reactive groups | Combination processes – Plasma / 3D print

Center for tribological coatings

Dr.-Ing. Jochen Brand[21]
Extension: 600
jochen.brand@ist.fraunhofer.de
System analysis and system optimization | Tribological coatings | Tribotesting | Device conceptions

Micro and sensor technology

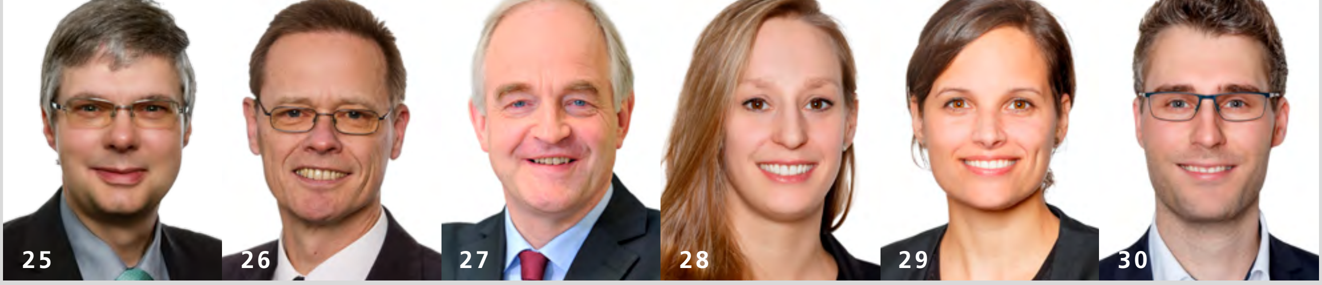
Anna Schott, M. Sc.[22]
Extension: 674
anna.schott@ist.fraunhofer.de
Wear-resistant thin-film sensors for temperature, force, wear and distance measurement | Microstructuring 2D and 3D of functional coatings | Sensor modules for forming processes | Sensorized washer systems

Tribological systems

Dr.-Ing. Martin Keunecke[23]
Extension: 652
martin.keunecke@ist.fraunhofer.de
Prototypes and small volume production | Plasma diffusion | Cleaning technology | Mechanical engineering and automotive technology | Carbon-based coatings (DLC) | Hard and superhard coatings | Wetting behavior | Tool coating (forming, cutting, chipping)

Dortmunder OberflächenCentrum (DOC)

Dipl.-Ing. Hanno Paschke[24]
Phone: +49 231 844 5453
hanno.paschke@ist.fraunhofer.de
Duplex treatment through plasma nitriding and PACVD technology | Boracic hard coatings | Tool coating | Coatings for hot forming | Coatings for industrial knives | Fuel cells



Application center for plasma and photonics

Dr.-Ing. Jochen Brand[21]
Extension: 600
jochen.brand@ist.fraunhofer.de

Prof. Dr. Wolfgang Viöl[25]
Phone: +49 551 3705-218
wolfgang.vioel@hawk-hhg.de
Plasma particle coating and cold plasma spraying | Plasma sources conception | Plasma treatment of natural products | Laser plasma hybrid technology for micro structures and surface modification | Laser technique for material treatment and characterization

Analysis and quality assurance

Dr. Kirsten Schiffmann[26]
Extension: 577
kirsten.schiffmann@ist.fraunhofer.de
Chemical microscopy and surface analysis | Microscopy and crystal structure | Test engineering | Costumer specific test engineering | Order investigation

Fraunhofer project center for energy storage and systems ZESS

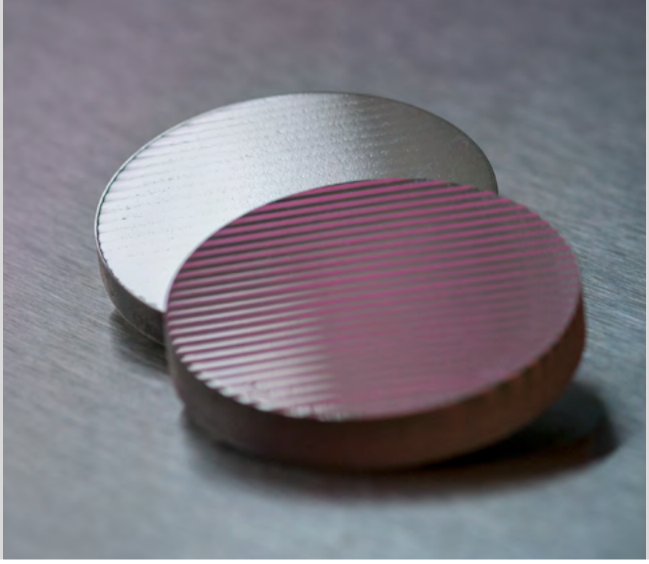
Prof. Dr.-Ing. Arno Kwade[27]
Phone: +49 531 391-9610
arno.kwade@ist.fraunhofer.de
Development of mobile and stationary energy storage devices and systems | Development and scaling of process technologies | Production of solid-state batteries

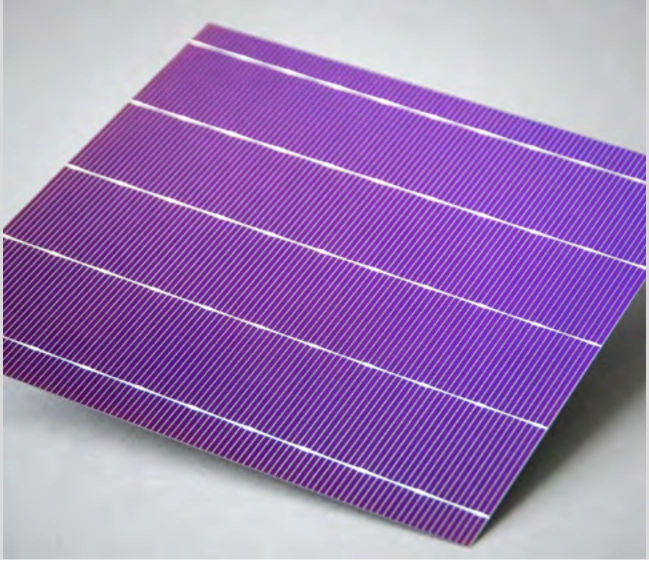
Process technology and production engineering

Dipl.-Ing. Sabrina Zellmer[28]
Extension: 528
sabrina.zellmer@ist.fraunhofer.de
Product and production systems | Energy storage development and production engineering | Production Engineering | Sustainable Factory Systems | Life Cycle Management

Energy storage development and production engineering
Dipl.-Ing. Jutta Hesselbach[29]
Extension: 613
jutta.hesselbach@ist.fraunhofer.de
Coating and functionalization of surfaces and particles | Production of anode/cathode materials and solid-state electrolytes | Formulation strategies for solid-state batteries | Electrode production | Characterization from material to cell

Sustainable factory systems and life cycle management
Stefan Blume, M.Sc.[30]
Extension: 532
stefan.blume@ist.fraunhofer.de
Battery cell manufacture | Data mining and data analytics | Model-based planning, simulation and operation of battery production systems | Cyber-physical production systems | Economic and ecological life cycle analyses





SERVICES AND COMPETENCIES

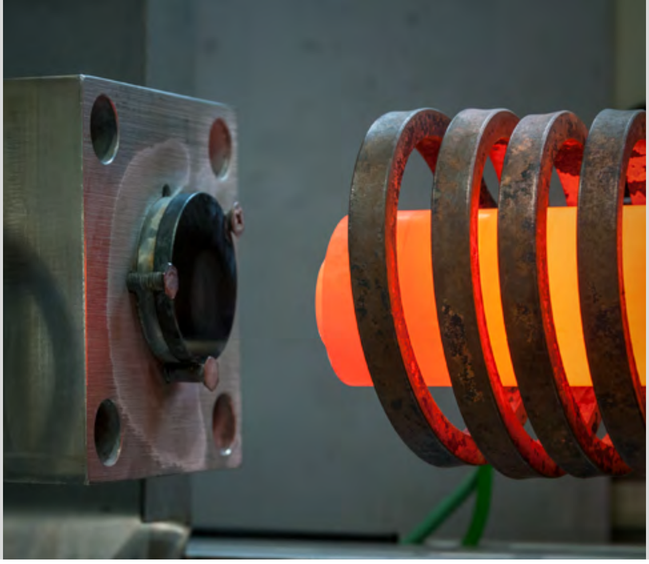
Based on the mission statement of sustainability, Based on the mission statement of sustainability, we create systems from the material through the process to the component, from the process chain to the factory, to recycling.

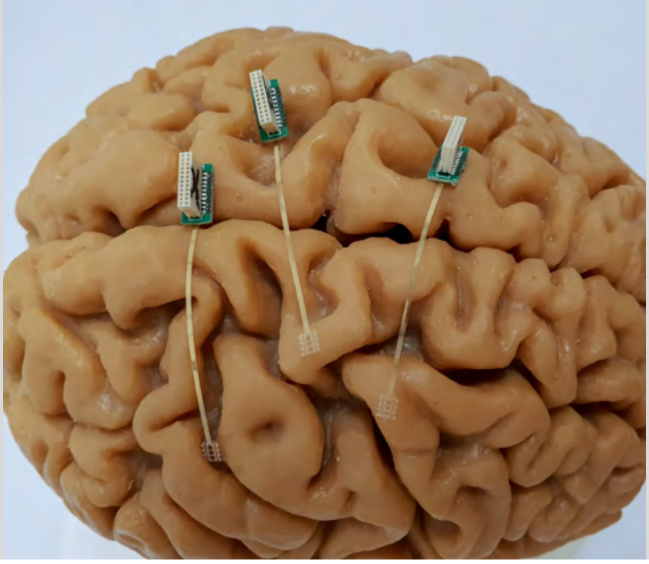
Thin film engineering: process and coating systems

- Pretreatment (e.g. cleaning on aqueous basis, plasma cleaning, Wet-chemical etching pretreatment, particle beam)
- Surface modification and coating
- Development of customer-oriented processes, coatings and layer (siehe Kompetenz Schichtsysteme, Seite 80)
- Simulation and modeling of surfaces, layer systems and coating processes
- Process technology (including process diagnostics, modeling and control)
- Development of system components
- Toolbuilding and plant engineering

Process technology and production engineering

- Development of mobile and stationary energy storage systems
- Electroplating 4.0
- Combination methods, e.g. 3D print with plasma
- Adhesive-free joining process
- Life Cycle Management: environmental and economic life cycle analysis
- Sustainable factory systems: model-based planing, simulation and operation of production systems
- Cyber-physical production systems (CPPS)



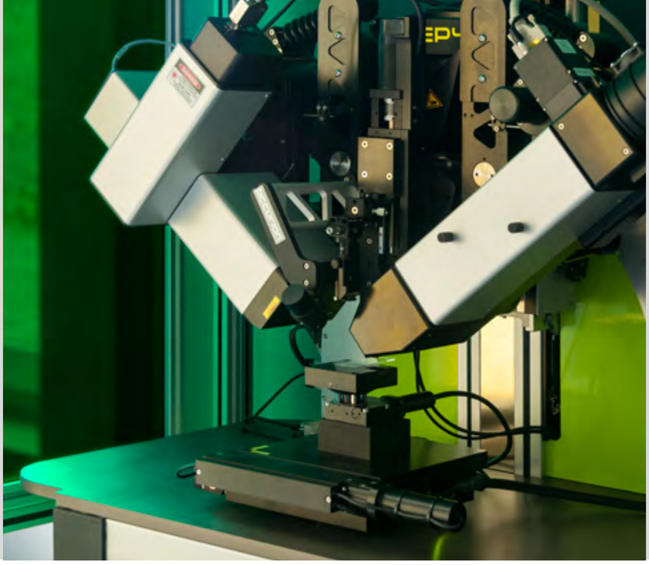


Analytics and quality assurance

- Micro- and surface analysis
- Microscopy and structure analysis
- Optical and electrical characterization
- Plasma diagnostics and simulation
- Production control and damage analysis
- Costumer specific test engineering
- Order investigation, 24-hour-service

Technology transfer

- Cost-of-ownership calculations, development of economical production scenarios
- Prototype development, pilot production and sample coating procedures
- Equipment concepts and integration into manufacturing lines
- Design of process chains and production systems
- Research and development during production
- Consulting and training



ANALYTICS AND QUALITY ASSURANCE

Chemical and structural analysis

- Energy-dispersive X-ray spectroscopy (EDX)
- Electron microprobe (WDX, EPMA)
- Secondary ion mass spectrometry (SIMS)
- X-ray photoelectron spectroscopy (XPS)
- Glow discharge optical emission spectroscopy (GDOES)
- X-ray fluorescence analysis (RFA / XRF)
- X-ray diffractometer (XRD, XRR)
- FTIR spectrometry (ATR, Mikroskopie, IRRAS, DRIFT)
- Raman spectrometry (532 nm, 633 nm, 785 nm, SERS, TERS)

Microscopy

- Scanning electron microscope (SEM)
- SEM with focused ion beam (FIB)
- Scanning tunnel and atomic force microscope (STM, AFM)
- Confocal laser microscope (CLM)
- Photo optical microscopes

Mechanical tests

- Micro and nano indentation (hardness, Young's modulus)
- Rockwell and scratch test (film adhesion)
- Cross-cutting test, butt-joint test (film adhesion)
- A variety of methods for the measurement of film thickness
- A number of profilometers

Measurement of optical properties

- IR-UV-visible spectrometry
- Ellipsometry
- Colorimetry
- Angular-resolved scattered light measurement (ARS)
- Integral scattered light measurement (Haze)

Measurement of friction, wear and corrosion

- Pin on disk tester
- Ball-cratering test (Calo)
- Wazau high-load tribometer (in air, in oil)
- CETR high-temperature tribometer (in air, in oil)
- Plint roller tribometer (in air, in oil)
- Taber abraser test, abrasion test, sand trickling test, Bayer test
- Microtribology (Hysitron)
- Impact and fatigue tester (Zwick Pulsator)
- Salt spray test, environmental tests, sun test

Specialized measurement stations and methods

- Characterization of solar cells
- Measuring station for photocatalytic activity
- Contact angle measurement (surface energy)
- Measuring systems for electrical and magnetic coating properties (e.g. Hall, Seebeck, conductivity, vibration magnetometer VSM)
- Test systems for electrochemical wastewater treatment

- Measuring stations for the characterization of piezoresistive and thermoresistive sensor behavior
- Biochip reader for fluorescence analysis
- Layer mapping system (0.6 x 0.6 m^2) for reflection, transmission, Haze and Raman measurement
- In-situ bondenergy measurement
- Electrochemical measurement stations (CV measurement)
- Wet chemical rapid tests: colorimetrical determination of ion and molecule concentrations
- Weathering tests: cyclical simulation of UV and rain exposition
- Zeta potential measuring instrument for surfaces

Plasma diagnostics

- Absorption spectroscopy
- Photoacoustic diagnostics
- Laser induced fluorescence LIF
- High-speed imaging
- Optical emission spectroscopy OES
- Retarding field energy analyzer RFEA
- Fiber thermometry
- Electrical performance test
- Numerical modeling


SPECIAL EQUIPMENT

Low pressure plasma processes
- a-C:H:Me, a-C:H, hard coating production plant
- (up to 3 m^3 volume)
- Coating facilities incorporating magnetron and RF diode sputtering
- Sputter plant for high-precise optical coatings
- In-line coating facility for large-surface optical functional coatings (up to 60×100 cm^2)
- Industrial scale HIPIMS technology
- Plants for plasma diffusion
- Coating systems for hollow cathode processes
- Clean room – large area coating (25 m^2)

Chemical vapor deposition
- Coating plant for thermal and plasma atomic layer depos-it-ion (ALD) (2D and 3D)
- Hot-filament-CVD units for crystalline diamond coatings (up to 50×100 cm^2) and for internal coatings
- Hot-filament-CVD unit for silicon-based coatings (batch process and run-through process up to 50x60 cm^2)
- Plasma-activated CVD (PACVD) units, combined with plasma nitriding

Atmospheric pressure plasma systems
- Atmospheric pressure plasma systems for coating and functionalization of large areas (up to 40 cm widths)
- Microplasma plants for selective functionalization of surfaces (up to Ø = 20 cm)
- Bond aligner with an integrated plasma tool for wafer pretreatment in the clean room
- Roll-to-roll set-up for area-selective functionalization of surfaces up to 10 m/
- Machine for internal coating of bags or bottles
- Mobile atmospheric pressure plasma sources
- S1 bio plasma laboratory with safety workbench

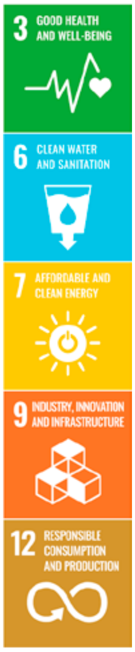
Laser technology and microstructuring
- Laser for 2D and 3D mikrostructuring
- Automated system for deposition of polyelectrolyte
- 2 mask aligner for photolithographic structuring
- Laboratory for microstructuring (40 m^2 clean room)
- Clean room – sensor technology (35 m^2)
- Laser structuring laboratory (17 m^2)
- Nanosecond dye laser (Nd: YAG-Laser)
- CO_2-Laser and Excimer-Laser
- EUV spectrography
- Semiconductor laser
- Picosecond laser

Electroplating

- System for electroplating metallization of waveguides (11 active baths with a volume of each 140 l and 1 nickel bath with a volume of 400 l)
- Modular technical electroplating system (20 stations for active baths with a volume of each 20 l)
- Anodizing plant (11 active baths with a volume of each 140 l and 2 anodizing baths with a volume of each 350 l)

Pretreatment

- 15-stage cleaning unit for surface cleaning on aqueous basis
- Glassware cleaning plant
- Particle beam plant
- Sputter plant and plasma jets for plasma cleaning



SUSTAINABLE DEVELOPMENT GOALS

Sustainability is perhaps the most important societal guiding principle of our time. Across the globe, sustainable development processes occupy first place on the agenda. In 2015, the United Nations adopted the 17 UN Sustainable Development Goals (SDGs) - an important milestone in sustainability policy. The Fraunhofer IST has also anchored sustainability in its mission statement. For the work at the institute, objectives 3, 6, 7, 9 and 12 are particularly relevant; in this context, selected activities at the Fraunhofer IST are presented below. Furthermore, projects and developments are constantly being addressed at the institute which support further or other goals.

SDG 3: Health and well-being

The improvement of health care and medical care as well as the reduction of diseases and deaths due to e. g. exposure to pollutants are fundamental goals of the UN.

Lower pollution levels

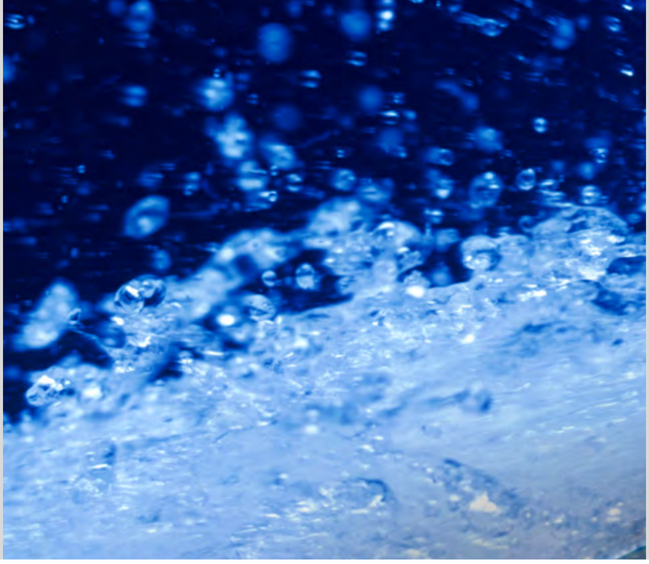
Pollutants in the air or water are frequent causes of disease. The Fraunhofer IST is developing photocatalytic films which decompose these pollutants. Furthermore, the institute is participating in projects which address the purification or treatment of water: diamond-coated electrodes utilize electrochemical oxidation in order to kill microorganisms and decompose organic pollutants (see also SDG 6: Clean water).

Innovative medical products

In the field of health care and medical care, the development of innovative medical products and the further development of existing items is an important success factor. The Fraunhofer IST performs research in this area, for example into the production of 3D-printed biodegradable polymer framework structures – known as scaffolds – which should be applied in the treatment of missing bone fragments. They serve as a framework for newly growing bone cells and subsequently decompose over time in the body. The Fraunhofer IST is also developing coating technologies on the basis of atomic layer deposition (ALD), in order to produce thin diffusion barrier films for implants.

Disinfection of surfaces

The killing of fungal spores to protect wood, the sterilization of packaging materials, and the disinfection of food or seeds are all examples of the challenges to the improvement of health and well-being within the context of sustainability goals. At the Fraunhofer IST, atmospheric-pressure plasma processes are being developed in order to enable the disinfection of even temperature-sensitive or unstable surfaces. The utilization of physical plasmas is fast, energy-efficient and environmentally friendly and can, in many cases, replace wet-chemical processes which are, to some extent, ecologically questionable. One possibility for the chemical-free wet-cleaning of surfaces is ozonized water, which can be produced using the diamond electrodes developed at the Fraunhofer IST.



SDG 6: Clean water

Enabling access to clean water for all people worldwide is an important goal of the UN. Furthermore, clean water also plays a significant role in the germ-free production of, for example, food or medical products.

Clean (drinking) water for rural areas

In developing countries – in particular in rural areas - many people are today still without access to clean water. Numerous projects are currently addressing the development of new procedures for supplying these areas with clean water. One possibility for this is to purify and treat water from seas, lakes, rivers or wells. At the Fraunhofer IST, a system has been developed in which diamond-coated electrodes are used to disinfect the water. Electrochemical oxidation is thereby utilized to kill fungi, algae, bacteria and viruses and to decompose organic pollutants.

Aseptic (food) production

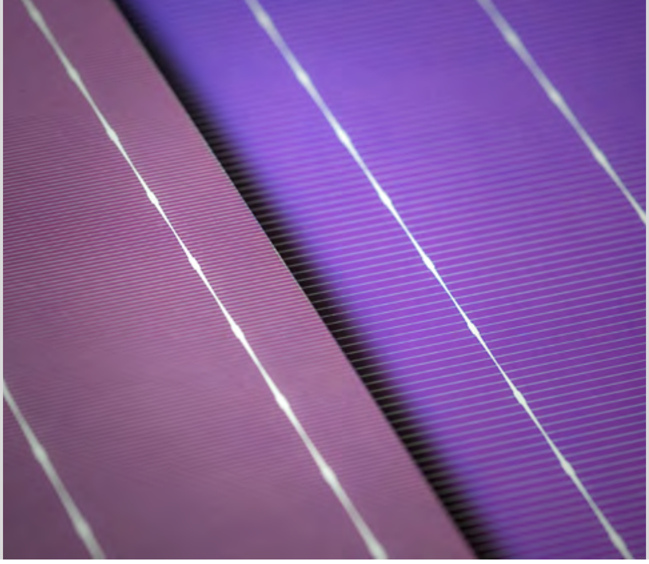
In the production of food and in the fields of medical technology and pharmaceuticals, ultrapure water is an indispensable starting material. The plants for the production of ultrapure water are, however, often colonized by germs after a certain period of time. The Fraunhofer IST is researching possibilities for cleaning these plants without the utilization of chemicals. One environmentally friendly and cost-efficient solution is presented by optimized cold sanitization using boron-doped diamond layers. This is based on an electrochemical process and requires neither additional chemicals nor increased temperatures. In order to prevent the formation of deposits on technical surfaces, known as fouling, the Fraunhofer IST is furthermore additionally developing special halogen-free non-stick coatings.

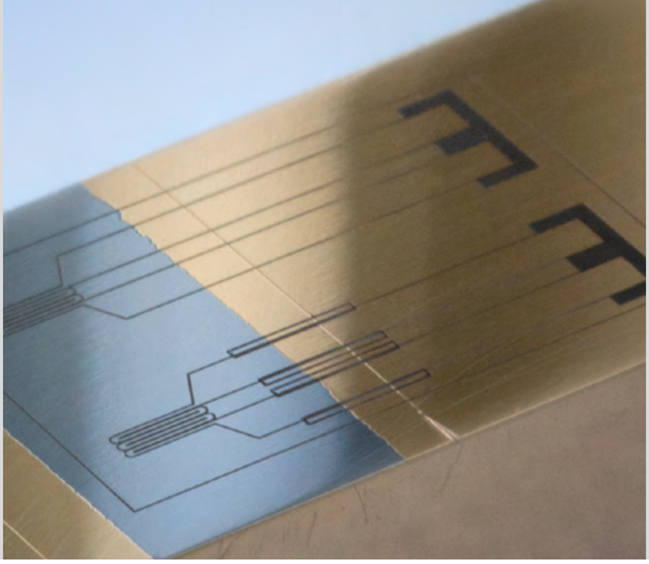
SDG 7: Affordable and clean energy

Against the background of climate change, energy generation utilizing wind, sun or water is playing an increasingly important role. Simultaneously, it is necessary to develop possibilities for using the available energy more efficiently.

More efficient use of energy

Film systems from the Fraunhofer IST help to increase energy efficiency. One example of this is erosion-control films on aircraft engines. Very hard multilayer films comprised of ceramic and metal prevent excessive fuel consumption and decreasing efficiency. A further example is the development of electrochromic coatings for windows, which can, for example, reduce solar radiation in buildings, thereby lowering the air-conditioning costs. Energy optimization and efficiency improvements are also a topic in the sustainable factory planning offered by the Fraunhofer IST. So-called "data mining" in production - from data acquisition through to evaluation by means of machine learning methods – enables the identification of "drivers" as regards energy and resource consumption.





Energy storage for electric mobility
Energy storage technologies which are safer and more efficient are gaining constantly in importance in view of the heralded energy revolution and the anticipated boom in electric and hydrogen mobility. The institute is working intensively on, amongst other items, the development of functional films for batteries of both present and future generations, which increase the performance capabilities and service life of these systems for mobile and stationary applications. Furthermore, high-performance coatings are being developed for bipolar plates utilized in fuel cells and electrolyzers.

Clean energy from the sun
In order to promote the use of renewable energies, the technologies for energy generation must also be further developed. In this field, the Fraunhofer IST is addressing the development of solar cells with increased efficiency. Two specific examples are the production of semiconductor films for thin-film and silicon-based photovoltaics and the development of characterization methods for thin-film solar cells. In collaboration with the Fraunhofer institutes IKTS and CSP, the Fraunhofer IST is currently conducting research into modules for photocatalytic water splitting in order to produce hydrogen as an energy source.

SDG 9: Industrialization, innovation and infrastructure

Innovation research is an important keyword with regard to the sustainable and positive economic development of a society.

Sustainable industrialization through sensor technology
In the era of Industry 4.0, the networking of production, logistics and customers is becoming increasingly important. Digitalization and automation of differing production processes play a major role in the development of sustainable industrialization. The Fraunhofer IST is therefore performing research into the development of various thin-film sensors which enable force, pressure, strain or temperature measurements. So-called "smart tools", intelligent tools with extended functions, enable highly accurate measurements of loads in a multitude of industrial application fields, increase production efficiency, and contribute towards fulfilling heightened safety requirements. As an example, modules with thin-film sensor systems are integrated into thermoforming devices and propulsion machinery in order to ensure a more efficient forming and processing of components.

Sustainable factory planning
A prerequisite of sustainable industrialization is an analysis of different life cycles. The Fraunhofer IST is therefore working on target-oriented and systemic factory planning in the field of battery cell production. Model-based planning, simulation and the operation of battery production systems are important factors thereby. The activities of the institute encompass the complete life cycle of battery systems – from raw materials through to battery recycling – and focus equally on technical, economic and ecological issues.

Innovation through simulation
The simulation and modelling of coating processes forms an important foundation for innovation. Based on data from a process simulation carried out at the Fraunhofer IST, it was possible to construct, for example, a "digital twin", which enabled the development of highly complex precision optical filter systems.

SDG 12: Sustainable consumption and production patterns

The increasing scarcity of raw materials makes the development of sustainable consumption and production patterns an important goal for the UN.

More efficient use of resources

At the Fraunhofer IST, innovative processes and materials are developed which reduce the use of raw materials during production. As an example, combination processes of atmospheric-pressure plasma procedures and electrochemical methods enable a more precise application of materials. Moreover, optimized hard-material and nanostructured film systems for forming, cutting or machining tools extend the service life of diverse facilities, which leads to a more economical and therefore resource-saving production. Furthermore, the development of new materials also plays an important role. By combining existing films and basic bodies, materials with new properties are realized at the institute.

Simulation-supported production

A further thematic focus at the Fraunhofer IST is presented by the field of simulation and modeling. Simulations enable ever-shorter development times; highly efficient production chains, for example, can be realized through the model-based design and implementation of coating processes. Furthermore, by coupling specific simulation models, interactions between products and production systems become evaluable, thereby enabling savings potentials to be made visible. The development of cyber-physical production systems enables a more sustainable production design. Through the use of so-called "digital twins", design alternatives can be analyzed in real time.

Less waste

Recycling is an important keyword for the work at the Fraunhofer IST. In order to reduce the amount of waste and simultaneously promote the more environmentally friendly handling of chemicals, the institute is carrying out work in the fields of material development and substitution. Examples include the development of alternative materials and production processes, with the aim of replacing diverse environmentally harmful substances such as indium tin oxide (ITO) or chromium (VI).

MECHANICAL ENGINEERING, TOOLS AND AUTOMOTIVE TECHNOLOGY

In the business unit "Mechanical Engineering, Tools and Automotive Technology", coating systems for friction reduction as well as for wear and corrosion protection are developed and optimized for specific applications. This encompasses the entire process: from cleaning and pretreatment by means of structuring and diffusion treatments, to coating and process development – including analysis and simulation – and on to integration into industrial applications. With a comprehensive portfolio of coating and treatment processes, the Fraunhofer IST is active in both industrial and public projects in a diverse range of application areas such as:

- DLC and hard coatings for motor, drive and bearing components
- Tools for the ecologically and economically optimized processing of lightweight materials such as aluminum, titanium, ultra-high-strength steels, polymers, etc.
- Highly corrosion-resistant and wear-resistant carbon coating systems for sealing applications
- Coating of original tooling and forming dies
- Surfaces for batteries and fuel cells
- Wear-resistant non-stick and antifouling coatings for the food and pharmaceutical industries

The advancing digitization of production processes and products also forms the focus of research activities at the Fraunhofer IST. Sensor-integrated surfaces enable the direct ascertainment of widely varying process parameters such as temperature, force, wear, and position in the production processes, thereby forming the fundament for the consistent digitization and flexibilization of autonomous production facilities. So-called "smart" tool surfaces offer new possibilities for predictive maintenance and, consequently, for increasing the productivity of manufacturing processes.

Sensory surfaces are developed and successfully deployed at the Fraunhofer IST in a diverse range of safety-relevant applications. Examples include:

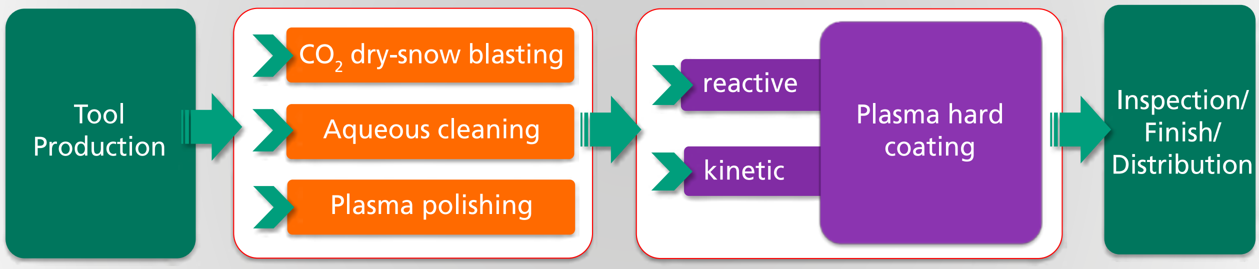
- Sensory washers for continuous force monitoring
- Pressure and temperature thin-film sensors for highly stressed tools and components
- Magnetic functional coatings for high-precision positioning systems and magnetic labels

Furthermore, the additive production of polymeric and metallic workpieces offers versatile starting points for surface technology along the process chain. The activities of the Fraunhofer IST encompass the coating of powders in order to improve their processing, the application of atmospheric plasmas in the printing process in order to locally optimize the component properties, and subsequent surface treatment for the creation of functional surfaces.

In addition to coating manufacturers, our customers primarily include companies from the automotive industry, tool manufacturers and users as well as coating users from all fields of mechanical engineering.

King pin with complex guided conductor tracks of a photo-lithographic structured 200nm thin chromium layer.

Sustainable Development Goals per business unit



1

OPTIMIZED CLEANING CHAIN FOR THE PLASMA COATING OF TOOLS

During the production of cutting tools, state of the surface and edge-layer arise which require the most efficient cleaning procedure possible in order to allow the subsequent coating. With the aim to avoid the use of suitably aggressive wet-chemical cleaning agents and simultaneously create further technological advantages, the Fraunhofer IST successfully participated in a DBU joint project, together with partners from industry and research, in which an alternative cleaning process chain was developed and evaluated.

The cleaning process chain

The developed combinations of balanced pretreatment processes enable a high cleaning effect with significantly reduced environmental pollution. Simultaneously, additional technological functions, such as the adjustment of the cutting-edge geometry for geometrically complex cutting tools, are possible. This results in an economical alternative to conventional cleaning processes.

In order to increase the process reliability of the subsequent vacuum coating processes during production, the following individual process steps were examined in different combinations and evaluated by investigating the wear behavior of coated tools in machining tests:

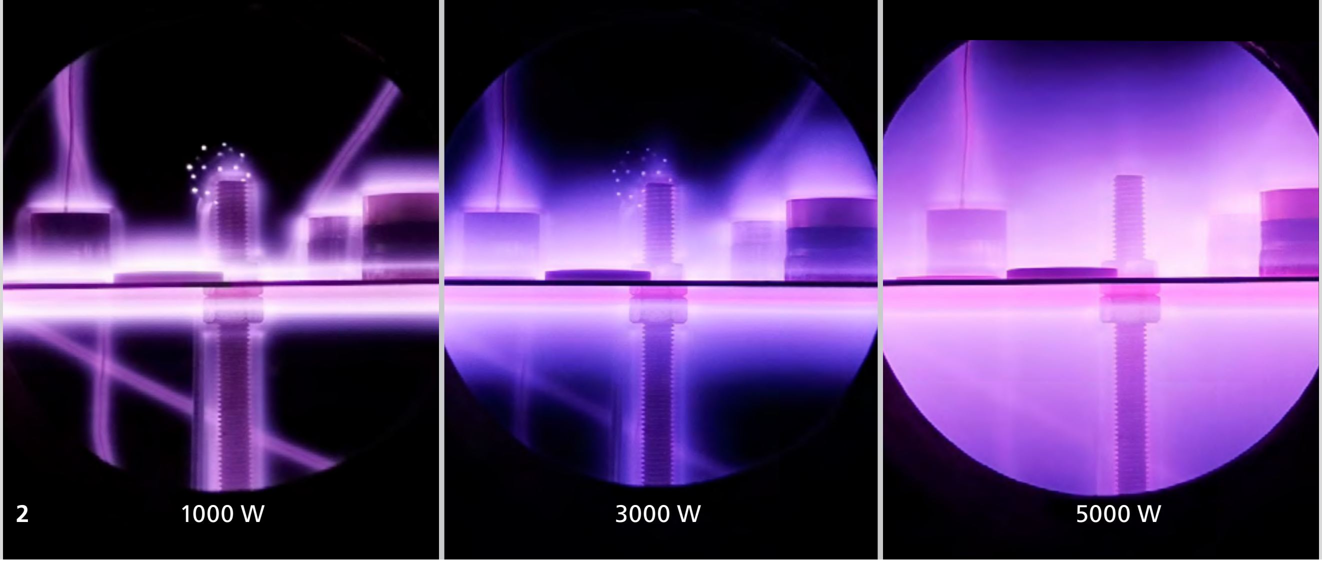
- Aqueous two-stage cleaning procedure with biodegradable cleaning agents
- CO_2 dry-snow blasting for local residue-free cleaning
- Plasma-electrolytical polishing with environmentally friendly media
- Plasma fine-cleaning in vacuum with novel generator concepts

The individual processes

As a further development of the state-of-the-art in production, a two-stage cleaning concept was selected for the aqueous cleaning process in such a way that the greatest possible effect can be achieved with the smallest possible application quantity. The intelligent combination of active ingredients is biodegradable and retains the pH values of the utilized aqueous cleaning agents within a moderate neutral range.

Working with the CO_2 snow jet, which is accelerated to supersonic speed, enables the efficient and gentle removal of particulate and film contamination such as dust, residues of polishing pastes, oils or cutting emulsions. This process can be automated and locally focussed for the cleaning of geometric areas which are difficult to access.

With plasma-electrolytical polishing (PEP), the component to be treated is cleaned and polished in an electrolyte of non-toxic salts and water by applying a voltage of several 100 V. In addition to very good cleaning results, burrs and impurities are removed in the same process step. Furthermore, the cutting-edge radii of the tools can be specifically adjusted.



2

For the final step of the pretreatment, the substrate surface at nanometer scale is cleaned from any chemical compounds under vacuum conditions by means of plasma-chemical and plasma-physical processes and chemically activated. This plays an important role, in particular as regards the bonding or adhesion of subsequently applied layers. Decisive for effective cleaning are the prevailing plasma conditions, which can be modified in wide ranges by varying the pulse geometry, acceleration voltages and plasma power (see Fig. 2).

Comparison of the individual cleaning processes

In the development of the process chain, various individual process combinations were applied to artificially contaminated cutting tools. In order to create the best-possible comparability, a synthetic reference contamination consisting of oils, fats, particles and suspensions used in the reference production chain was developed. Prior to the evaluation, the tools were qualified with regard to cutting-edge radii and surface roughness as well as coating adhesion. The maximum tool life of the tools was then determined in a machining test.

An evaluation of the results shows the direct influence of the individual processes in the respective chain:

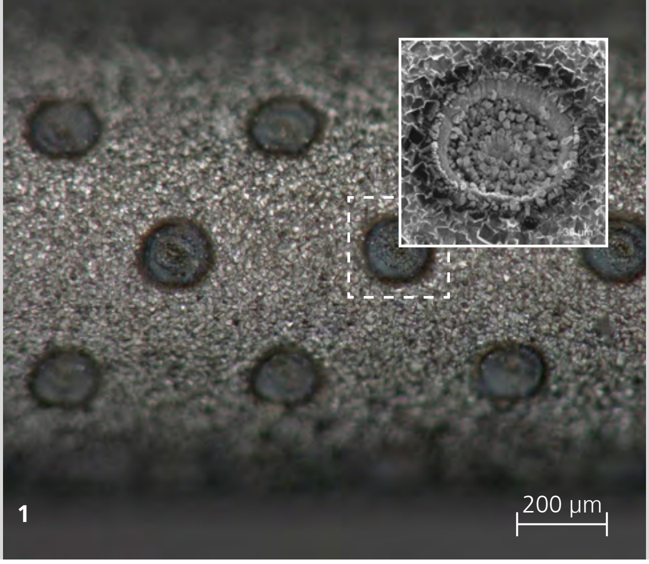
- All cleaning chains without plasma fine-cleaning exhibited a significantly lower coating adhesion and service life than batches with integrated plasma fine-cleaning.
- The optimized aqueous cleaning has no further influence in the chain, but as an individual process it is at least as good as the reference.
- CO_2-blasting has the technological advantage of a strongly locally fo-cused cleaning possibility.
- With PEP, in addition to the removal of heavy contamination, cutting-edge radii can also be adjusted.
- The combination of PEP with CO_2-blasting exhibits the highest overall relevance with regard to industrial usability. The sequence thereby se-lected shows no significant influence.

1 *Process chain in the project 'ÖkoClean', schematically.*

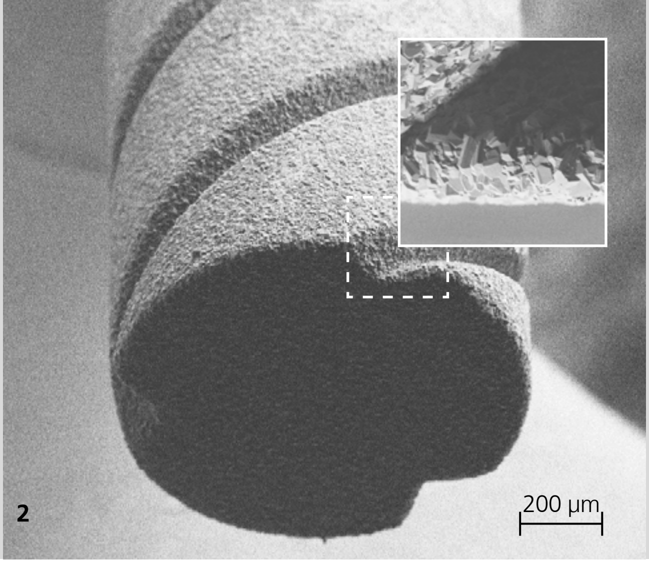
2 *Plasma fine-cleaning with pulsed plasma at differing plasma power levels.*

CONTACT

Dipl.-Ing. Hanno Paschke
Phone +49 231 844-5453
hanno.paschke@ist.fraunhofer.de



1



2

TEXTURED CVD DIAMOND MICRO ABRASIVE PENCILS

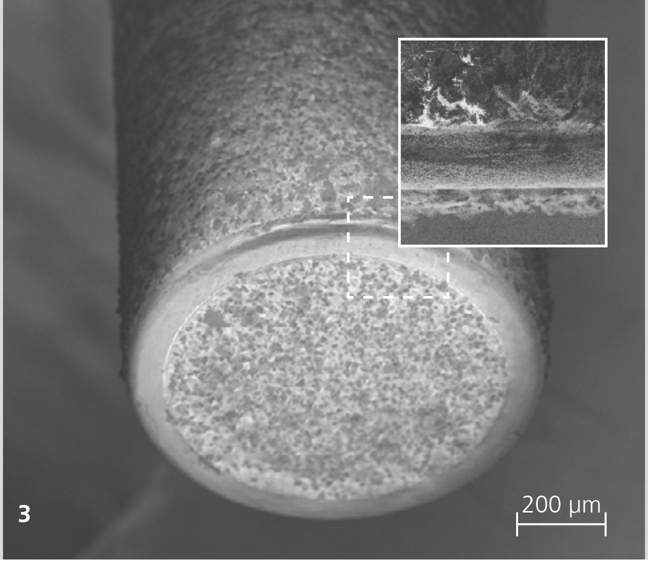
In collaboration with the Institute of Machine Tools and Production Technology (IWF) at the Technische Universität Braunschweig, Fraunhofer IST has developed novel CVD diamond micro abrasive pencils for particularly demanding grinding operations in which special precision and the highest possible surface qualities are required. The innovation of the presented tool concept lies in the combination of a polycrystalline CVD diamond layer as abrasive layer with the incorporation of additional grooves in the tool surface in order to create additional chip clearance. As a result, the supply of cooling lubricant is improved and consequently the performance capability of the tools is enhanced even further.

CVD diamond as high tech grinding layer

Due to their material properties and intrinsic surface topography, polycrystalline diamond coatings produced using hot-wire chemical vapour deposition (CVD) present an unsurpassed wear-resistant abrasive layer with extremely sharp and efficient micro cutting edges which seamlessly cover the entire tool surface. In contrast to conventional binder-based diamond abrasive layers, this abrasive layer consists entirely of diamond crystals with a very uniform size distribution. It is also possible to achieve any desired fine grain size without suffering the loss of bonding forces. As a consequence, CVD diamond abrasive layers are ideally suited for grinding operations in which the highest precision and quality of the workpiece surfaces is required with simultaneous low roughness and reduced sub-surface damage. Until now, the disadvantage of such fine abrasive layers had been that the CVD diamond layer provides very little space for the transport of cooling lubricant and the capture of chips. The solution approach at the Fraunhofer IST is to generate additional chip clearances and lubrication pockets by creating spiral grooves or bowl-shaped-cavities, thereby improving the performance efficiency of CVD diamond abrasive layers even further.

Concepts for adding additional surface textures

Two fundamentally different concepts for the creation of additional cavities were examined and realized. One was to incorporate cavities into the already finished diamond coating by using an Nd:YAG solid-state laser after the diamond-coating process. This method allows the practically freely-selectable introduction of almost any type of cavities even for abrasive pencil diameters of 0.2 mm and below (see Fig. 1). The second method entails machining the carbide base body by grinding-in e.g. spiral grooves and subsequently applying the CVD diamond layer (see Fig. 2). Both variants have been successfully implemented.



1 *CVD diamond abrasive pencil after laser texturing.*

2 *CVD diamond abrasive pencil with ground spiral grooves after machining of zirconia ceramic.*

3 *Conventional diamond abrasive pencil with electroplated bond (D15) after machining of zirconia ceramic, with the abrasive layer completely worn away at the tip edge.*

Achieved improvements

The innovative textured CVD diamond abrasive pencils have been successfully utilized for the machining of quartz glass, zirconia ceramics and hardened 100Cr6 rolling bearing steel. Compared to electroplated diamond abrasive pencils with grit size D15, the roughness of the machined surfaces was significantly improved. Even with experimental parameters for which conventional diamond abrasive pencils exhibited considerable wear - particularly in the area of the tool tips -, the textured CVD diamond tools showed absolutely no signs of wear (see Figs. 2 and 3). This work is currently still ongoing. At present, the textured CVD diamond tools are being tested in industrial use by several companies from the project's user committee. The application of the described concept is not limited to micro tools; it can also be transferred to other grinding tools like grinding wheels or honing stones accordingly.

The project

Gefördert durch:

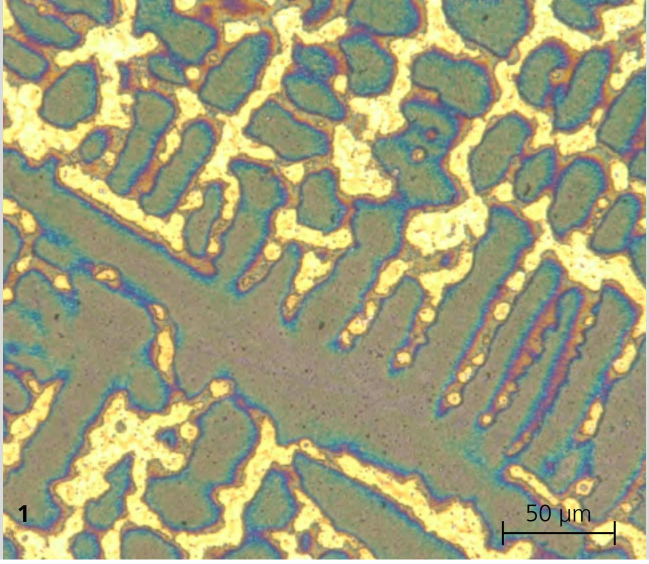
Bundesministerium für Wirtschaft und Energie

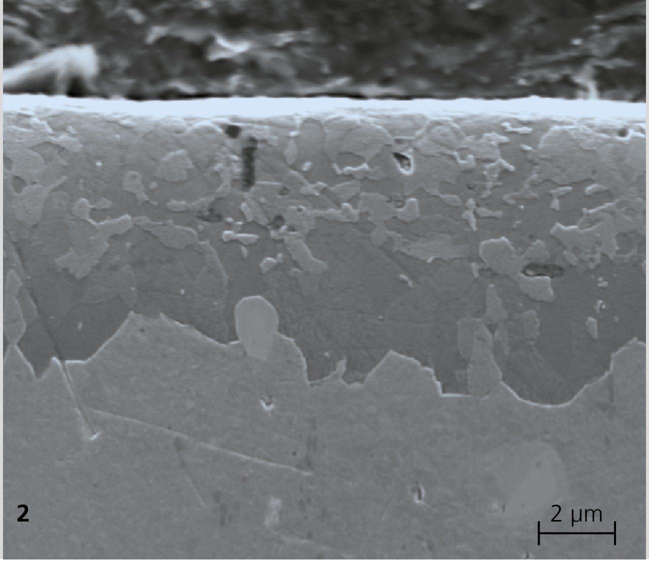
aufgrund eines Beschlusses des Deutschen Bundestages

The project was funded under the grant number 19664 N within the framework of the program for the support of the German Federation of Industrial Research Associations (IGF) by the German Federal Ministry for Economic Affairs and Energy on the basis of a resolution of the German Bundestag.

CONTACT

Dr. Markus Höfer
Phone +49 531 2155-620
markus.hoefer@ist.fraunhofer.de





SURFACE-LAYER TREATMENT OF HIGH-TEMPERATURE MATERIALS

The utilization of high-temperature materials such as nickel, molybdenum or cobalt-chromium base alloys is indispensable for many applications. This applies, for example, to thermally highly stressed forming tools or components for engine and turbine construction. Whilst the materials usually fulfill the strength requirements, in many cases the friction and wear behavior is unsatisfactory. The Fraunhofer IST has therefore developed surface-layer treatments which significantly improve the friction and wear behavior of these materials.

Application of high-temperature materials in toolmaking

One significant application of the aforementioned high-temperature materials is forming tools for the hot-forming of high-strength titanium alloys and titanium aluminides. At temperatures of up to 1200 °C, components for turbine and engine construction as well as medical technology are produced from them. At forming temperature, the tools must exhibit a higher strength than the materials to be formed at low friction, whilst simultaneously ensuring sufficient wear resistance in order to enable economical production.

The surface-layer treatment

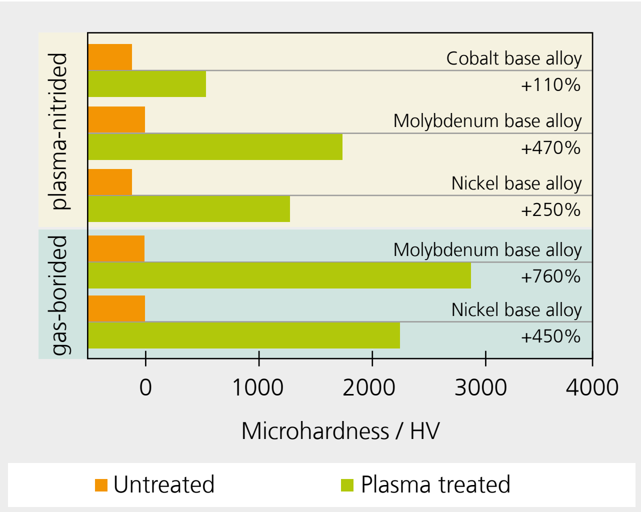
One possibility for increasing the hardness and wear resistance of metallic materials concerns diffusion processes such as nitriding and boriding. In these processes, nitrogen or boron diffuses into the material and alters the material properties in the peripheral zone. Prerequisites for this are that either nitrogen or boron is provided on the surface in a suitable reactive form, that it can penetrate into the material, and that the temperature is high enough to enable diffusion. Depending on the material to be treated and the process parameters, compound layers and precipitates can be formed, which lead to hardening of the surface layer. With nitriding, the reactive nitrogen is provided predominantly from the gas phase, often with plasma support. With boriding, powdered or paste-like dispensing media have been used almost exclusively up until now. The residues have to be laboriously removed following the process. For steel materials, these nitriding and boriding processes are state-of-the-art. Occasionally, nickel base materials are also boron-treated with powdered or paste-like dispensing media.

In an internal Fraunhofer research project, the application of plasma nitriding processes and a gas boriding process, newly developed at the Fraunhofer IST, was investigated regarding the surface-layer treatment of nickel, molybdenum and cobalt-chrome base alloys. For each of the materials, suitable treatment parameters could be identified, in which well-adhering surface layers with high hardness are formed. Through subsequent heat treatment, their properties can, in many cases, be further improved. Figure 2 shows the forming surface layer using the example of a gas-borated molybdenum base material.

Test procedure

The sample hardness was determined using a micro hardness tester from Fischer. A very small test load is thereby applied to measure the hardness of thin layers with spatial resolution. For the evaluation of the friction and wear behavior of the

3



surface-layer-treated high-temperature materials, a high-temperature tribometer is available at the Fraunhofer IST with which pin-on-disc tests can be carried out at temperatures of up to 1000 °C under a defined inert gas atmosphere or ambient air in differing load ranges. The coefficient of friction, the occurring wear, and any chemical and structural changes to the materials are evaluated.

The results

For nickel, molybdenum and cobalt-chromium base alloys, considerable increases in hardness in the peripheral zone could be achieved through adapted plasma-nitriding or gas-boriding processes. In the case of gas-borated nickel and molybdenum base alloys, the hardness could be increased to between 2500 and 3500 HV. Simultaneously, the coefficient of friction at forming temperature was reduced by up to 80 % compared to high-strength titanium alloys and titanium aluminides. Material build-up, one of the main causes of failure in untreated forming tools, could be completely avoided. Application tests in the hot-forming of titanium aluminides for the manufacture of turbine blades are currently in preparation.

1 *Microstructure of a cobalt-chromium base alloy.*

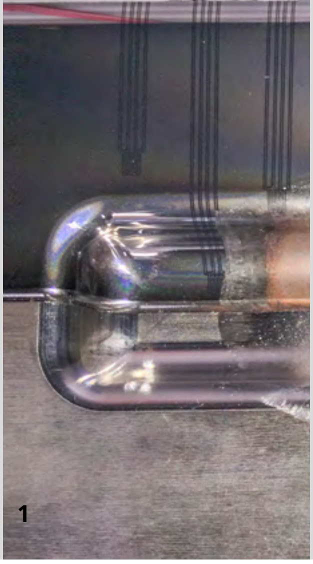
2 *Cross-section of a surface-treated molybdenum base alloy.*

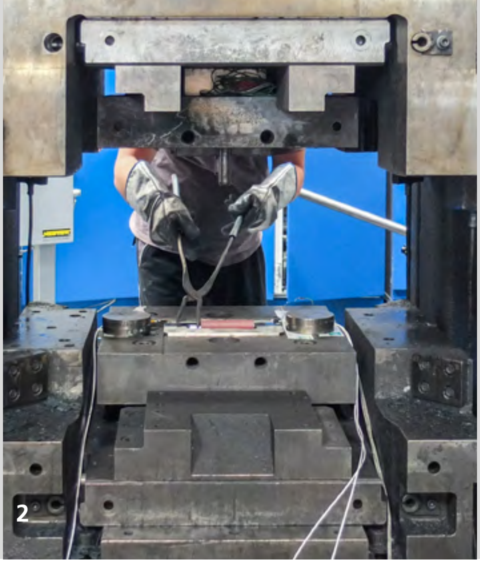
3 *High-temperature tribometer for friction and wear tests up to 1000 °C.*

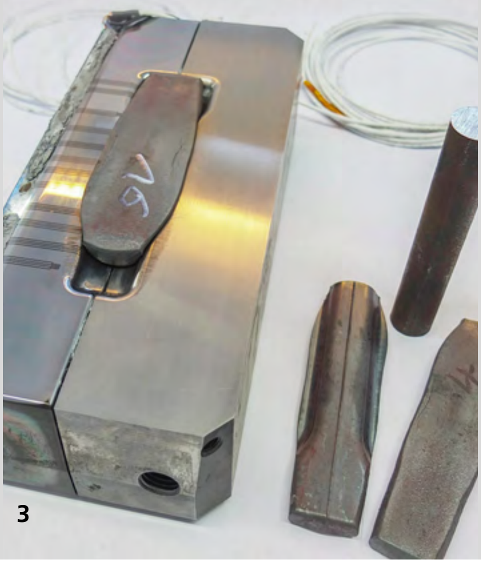
CONTACT

Markus Mejauschek, M. Sc.
Phone +49 531 2155-679
markus.mejauschek@ist.fraunhofer.de

Dipl.-Ing. Martin Weber
Phone +49 531 2155-507
martin.weber@ist.fraunhofer.de


1


2


3

ROBUST THERMORESISTIVE SENSOR TECHNOLOGY FOR WARM FORMING

In order to better understand tool-wear processes in warm forming, the actual temperature distributions across the tool surface during the forming process must be recorded. To determine these, a forging die is coated with a thermoresistive and simultaneously wear-resistant thin-film system (see Fig. 1) which, in direct contact with the glowing steel blank, measures the temperature distribution in the mold.

Structure of the coating system

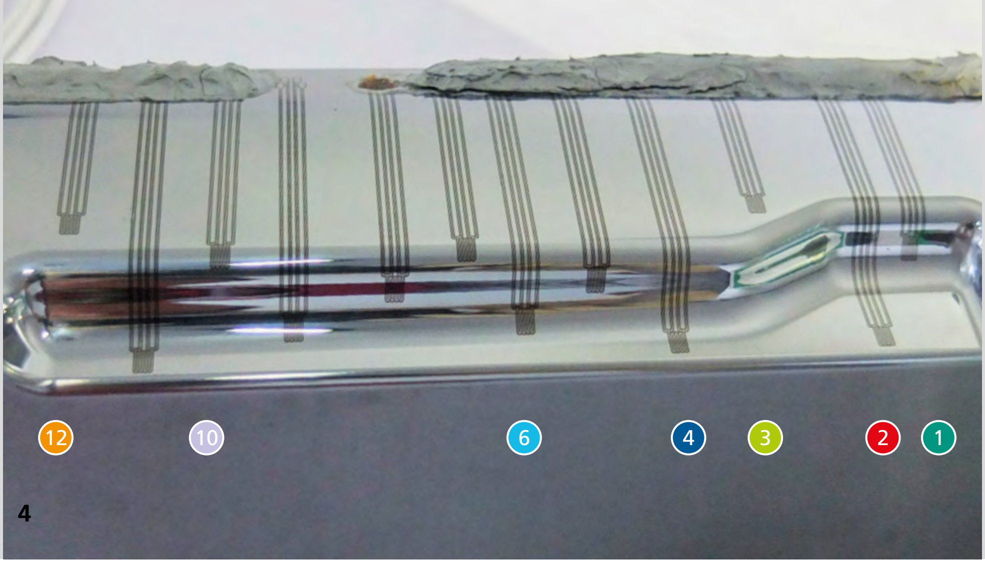
The sensory layer system is deposited on one half of the tool (see Fig. 1 – 3). Prior to receiving a primer coating of aluminum oxide (Al_2O_3) with a thickness of approx. 4.5 µm, the tool surface is polished in order to attain an average roughness depth of 0.1 µm. A 0.2 µm-thin chromium layer is then homogeneously deposited upon it. By means of photolithography and subsequent wet-chemical etching, the sensor structures, with their meandering shapes, are arranged in different areas of the tool (see Fig. 4). These thin-film sensors, whose conductor paths run from the forming area over complex contours into the unstressed contacting area, are covered with a second 3 µm-thick insulating and wear-protecting Al_2O_3 layer.

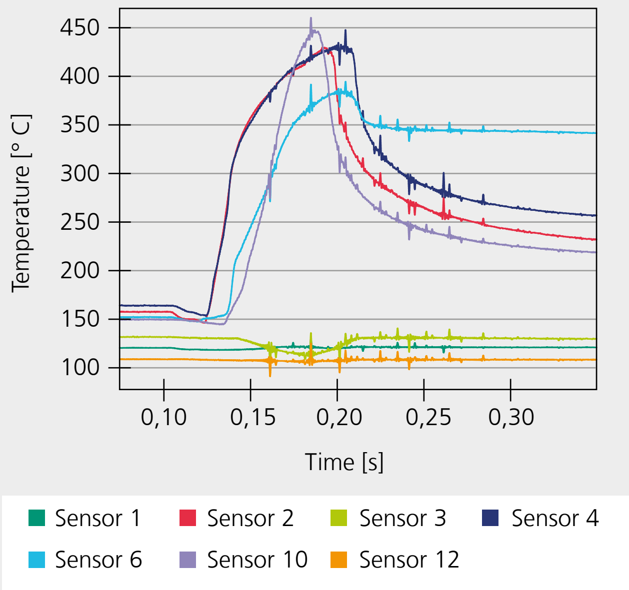
Measurements in the warm process

Figure 2 shows the sensory forging die installed in a press with the glowing steel blank for warm forming. In Figure 3, the position of the formed workpiece in the die is presented. The individual sensor structures measure the temperature distribution via four-wire technology with spatial resolution. A corresponding measurement progression is shown in the adjacent diagram. A force of 2600 kN and a strike height of 32.5 mm were selected as process parameters.

The project

These results were achieved within the project "Warm forging of steel with carbon-based coating systems (Halbwarm DLC2)", (funding ref. BR 2178/42-1), funded by the Deutsche Forschungsgesellschaft (German Research Foundation), in cooperation with the Institut für Integrierte Produktion Hannover gemeinnützige GmbH (IPH) and the Institute for Surface Technology IOT in Braunschweig.





Characteristic temperature curves of the individual sensor structures for a forming process (see Fig. 4).

1 *Two-part forming tool, coated on the upper half with the thermoresistive thin-film system.*

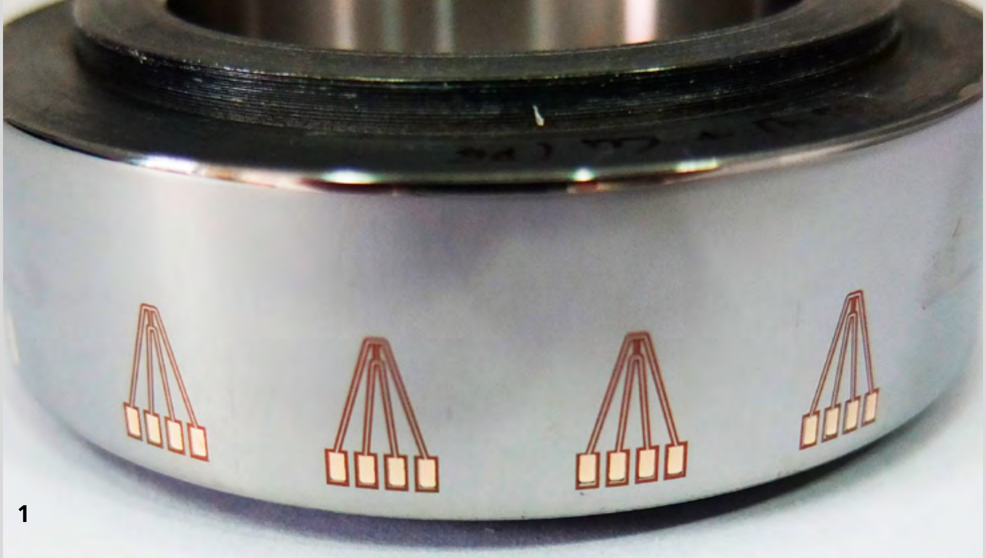
2 *Press with built-in sensory forging die. A glowing steel blank lies in direct contact with the thin-film sensors.*

3 *Reconstructed contact situation following the forming process.*

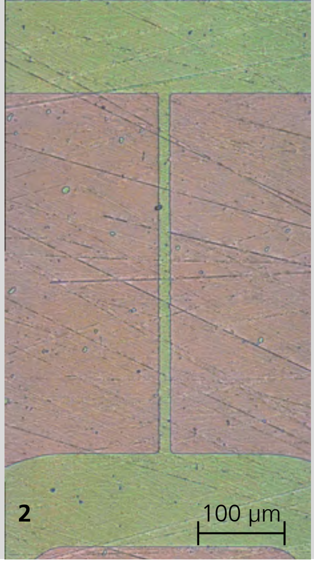
4 *Arrangement of the meandering sensor structures of the steel blank.*

CONTACT

Marcel Plogmeyer, M. Sc.
Phone +49 531 2155-661
marcel.plogmeyer@ist.fraunhofer.de



1



2

THIN-FILM SENSOR TECHNOLOGY IN MIXED-FRICTION-LOADED CONTACTS

For the optimization of partially or fully lubricated tribological systems, knowledge concerning the temperature in the lubrication gap is of great importance. In order to be able to create a better design for the scuffing load capacity of gear teeth, the temperature in the mixed-friction-loaded tooth-flank contact must be measured. Whilst thin-film sensor systems are suitable for this purpose, they are, however, subjected to very high wear in these contact zones. Within the framework of an AiF research project (No. 19330 BG), the Fraunhofer IST, in collaboration with its partners, is therefore developing a wear-resistant thin-film sensor system for the long-term stable measurement of temperatures in tooth-flank contacts which are subject to mixed-friction loading.

Film system with integrated temperature-sensor structures

The thin-film system is built-up directly on the polished surfaces of steel rings and gear-tooth flanks (R_z value of 0.1 µm). Aluminum oxide (Al_2O_3) is homogeneously deposited as a base layer in the form of an electrical insulation layer with a thickness of 4 – 6 µm. Subsequently, the samples are coated with 200 nm-thick chromium, which is structured using a combination of photolithography and wet-chemical etching. A steel ring with sensor structures is presented in Figure 1, whilst Figure 3 shows a gear wheel. Over the course of the project, it was possible to considerably reduce the minimum structure width down to 10 µm, which results in a high spatial resolution and sensitivity of the sensors. In conclusion, a 1 – 2 µm-thick layer of SiCON®, an amorphous hydrocarbon layer modified with silicon and oxygen (a-C:H:Si:O), is applied as an insulation and wear-protection layer. The thin-film system thereby has a thickness of less than 10 µm.

Characterization of the sensor structures

To record the thermoresistive resistance characteristics, the sensors are measured in a so-called four-wire circuit, i. e. a constant current is applied via two supply cables, and the voltage drop across the sensor is measured via two further cables. The sensor resistance is then calculated according to Ohm's law. During the measurement, the samples are located in a furnace, where they are initially heated to approx. 170 °C and then subsequently cooled down again to room temperature. The resistances of the individual sensor structures exhibit the linear dependence on temperature expected for metallic structures.

Temperature measurement in mixed-friction contact

The functionality of the thin-film sensors and their wear-resistance are tested in a series of experiments under mixed-friction conditions. The adjacent graph shows an example measurement of the temperature increase when the sensor is traversed.

3

4

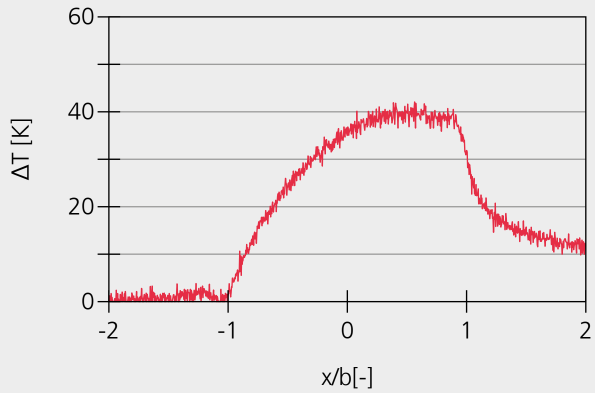
1–2 *Steel ring with sensor structures (1) and microscopic image of the 10 µm sensor structures (2).*
3–4 *Gear-tooth flank with sensor structures (3) and microscopic image of the 10 µm sensor structures (4).*

Outlook

In the future, the sensor system is to be further developed in such a way that pressures and gap heights can also be determined. Such a multi-sensory thin-film system could, in a next step, also be used in other contacts subject to mixed friction, such as rolling bearings, plain bearings or seals, whereby all three variables – temperature, pressure and gap height – can be measured either together or individually.

The project

The described results were achieved within the FVA project 789 I "Sensors for mixed-friction" on the topic of "Development of a robust thin-film sensor system for measuring the temperature in mixed-friction-loaded thermo-elastohydrodynamic contacts", on which the Fraunhofer IST was working in collaboration with the Institute for Machine Design (IMK) of the Otto von Guericke University Magdeburg. The project was funded by the German Federal Ministry for Economic Affairs and Energy (BMWi) on the basis of a resolution of the German Bundestag and the German Federation of Industrial Research Associations (AiF, funding project No.: 19330BG).



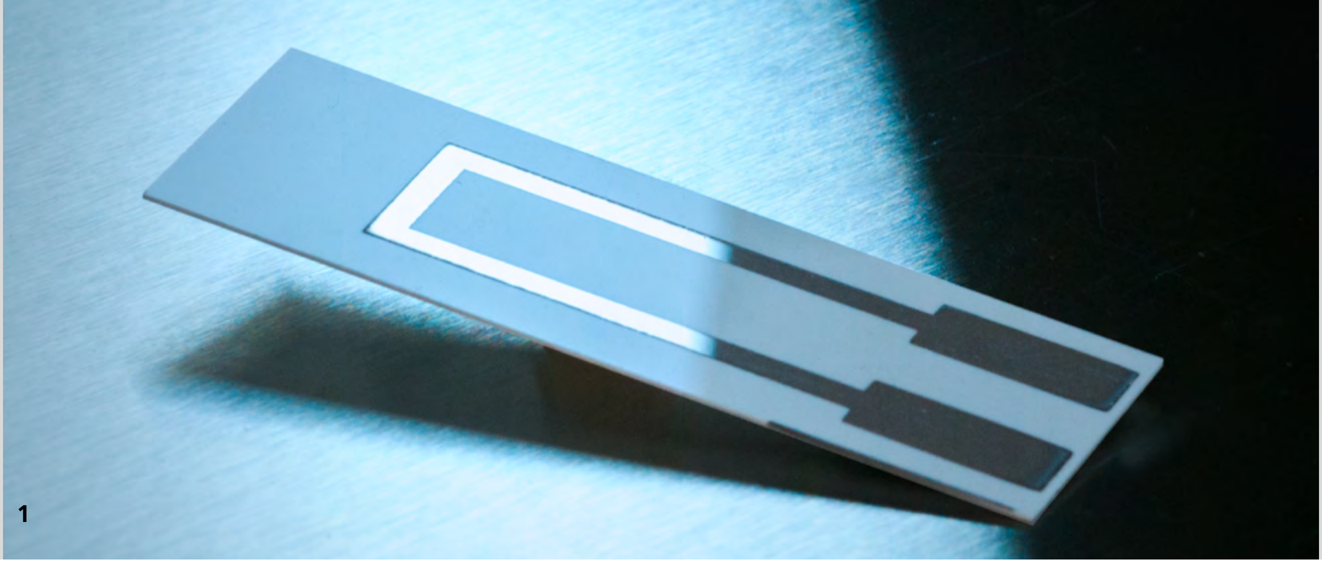
Experimental conditions

Sum velocity	2 m/s
Slip	40 %
Normal force	1,5 kN
Oil supply temperature	40 °C

Measured temperature increase in mixed-friction contact.

CONTACT

Marcel Plogmeyer, M. Sc.
Phone +49 531 2155-661
marcel.plogmeyer@ist.fraunhofer.de



1

MATERIALS FOR HIGH-TEMPERATURE STRAIN GAUGES

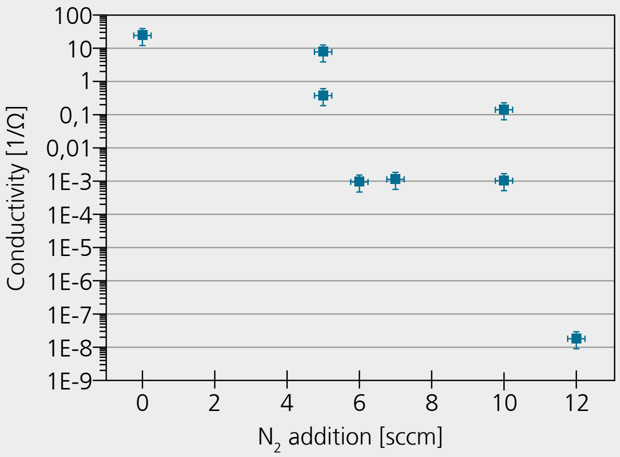
Strain gauges measure material deformations of the component to which they are attached, thereby enabling the display of (critical) forces, torques and other mechanical stresses during operation. Conventional strain gauges, however, reach their limits at higher temperatures of around 200 to 400 °C: Glued systems based on foils can no longer be used in such cases, and even directly applied strain-sensitive films, such as sputtered strain gauges, are difficult to implement. The temperature coefficients of the thin film layers are superimposed to the strain signal and, through oxidation, a continuous increase of the measured values can be observed. New approaches for strain-sensitive, temperature-resistant thin-film materials are therefore currently being researched at the Fraunhofer IST.

Example: Conductive nitrides, produced by means of gas-flow sputtering

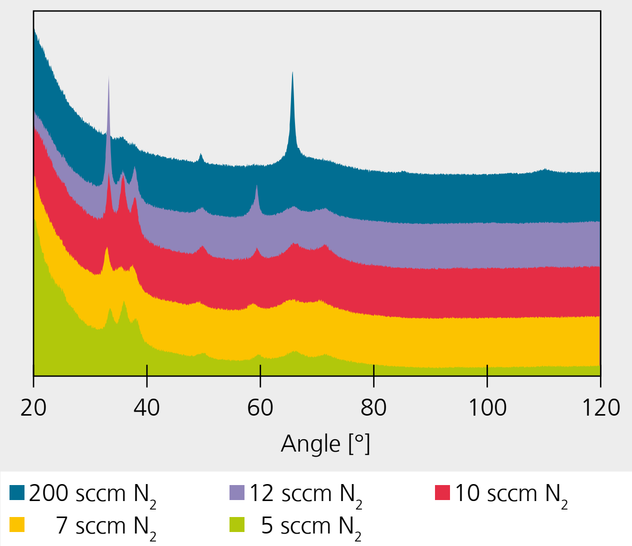
Inspired by publications from university research, conductive aluminum nitride (AlN) has become the focus of attention at the Fraunhofer IST. Aluminum nitride has long been known as a piezoelectric material. Stoichiometric AlN is chemically resistant, stable at high temperatures, and electrically insulating. Under special conditions, however, it can also be deposited conductively by means of gas-flow sputtering – a prerequisite for the application of AlN in piezoresistive strain measurement. In reactive gas-flow sputtering – in contrast to magnetron sputtering – there is no so-called hysteresis, i. e. no interaction between the metallic sputtering process and the addition of reactive gas. In this respect, extremely stable reactive sputtering processes can be realized. Depending on the addition of the reactive gas during the sputtering process, e. g. nitrogen, a particularly interesting non-stoichiometric transition range (AlN_x) can be set between the insulating phase and the aluminum-rich metallic phase.

The results

AlN_x layers with differing nitrogen additions were deposited with a thickness of 2 micrometers onto insulating surfaces. The electrical conductivity of the layers could be varied over eight orders of magnitude (see Figure 1). The chemical composition of the layers, the microstructure and the crystallographic properties were also determined. As expected, the samples produced using the lowest nitrogen addition exhibited the highest conductivity and the largest aluminum surplus. However, by means of X-ray diffraction, it could be shown that even for the lowest nitrogen additions, the hexagonal AlN phase is the predominant phase of the layers (see adjacent Figure below). The measured grain sizes decrease with lower nitrogen addition. Furthermore, a metallic aluminum phase could not be detected. An explanation can be offered by a structural model in which surplus aluminum is finely distributed in an AlN matrix, quasi as a dopant.



Electrical conductivity (logarithmic) of AlN_x layers as a function of nitrogen addition.



X-ray diffraction measurements on AlN_x layers show the hexagonal aluminum nitride phase in all cases, but with differing preferred orientations.

1 *Simplified strain gauge structure for determining the k-factor and the temperature coefficient of electrical resistance (TCR).*

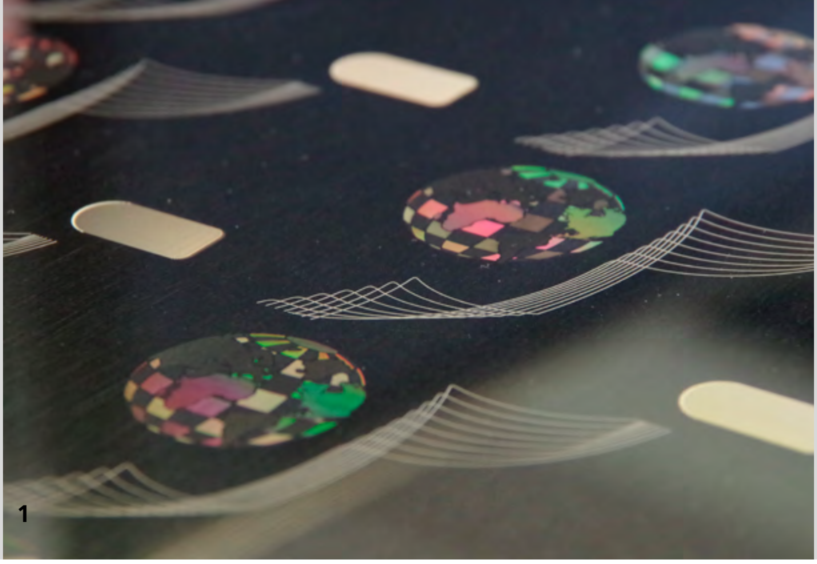
Outlook and applications

The present results represent solely an interim assessment of the ongoing development. Currently, the effects of a downstream annealing step in the vacuum furnace on the thermal stability and conductivity of the layers are being investigated. In the event of successful development, it will be possible in the future to use sputtered gauges on components subject to high thermal stress, such as compressor blades in gas or aircraft engines.

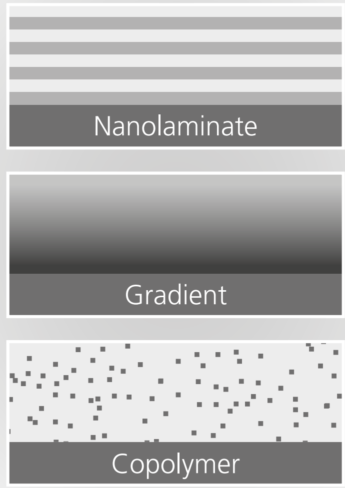
CONTACT

Dr. Kai Ortner
Phone +49 531 2155-637
kai.ortner@ist.fraunhofer.de

Dipl.-Phys. Holger Gerdes
Phone +49 531 2155-576
holger.gerdes@ist.fraunhofer.de



1



2

INNOVATIVE COMPOSITE LAYERS BY MEANS OF ATMOSPHERIC PECVD

Lamination plates are currently used, for example, in the production of documents such as passports, driving licenses, national identity cards and bank cards. The trend towards integrating more and more functions and features on such cards is, however, placing more intensive demands on the lamination process and on increasingly finer structures. Structures with a thickness of nm and a width of merely µm are desired on the film. At present, however, it is not possible to produce these as the adhesion between the substrate and the laminating tool is too high, as a result of which parts of the polymer remain stuck to the metal plate following the lamination process. The Fraunhofer IST is therefore working on a suitable non-stick coating for the surface of the lamination plates; this solution should solve these problems and, furthermore, enable the use of materials such as polyethylene terephthalate glycol and polyurethane (PET-G and PU) in the future.

The solution approach

Within the scope of the BMBF-funded project "MONK" (Funding ref.: 13XP5046), a new type of non-stick coating on the basis of composite materials was researched at the Fraunhofer IST. The coatings, which are produced from process gases with two different silicon precursors, are characterized by good adhesion to the substrate material and, at the same time, excellent non-stick behavior with respect to various polymers.

Innovative material classes with optimum surface properties

In a first step, potentially suitable layer-formers were selected, namely two silicon-containing compounds, one of which has adhesion-promoting properties and the other non-stick properties. The layer-formers were applied – sometimes also as a mixture – in order to produce three different types of composite coatings on the lamination plates by means of atmospheric-pressure plasma processes (see Figure 2):

1. Nanolaminate: This coating consists of two different individual layers of only a few nanometers in thickness, which are deposited alternately. The undermost layer is the adhesion-promoting layer, whilst the uppermost layer is the non-stick coating.
2. Gradient: The gradient layer is characterized by two precursors which change their concentrations in opposite directions across the layer thickness in order to achieve a smooth transition from the adhesion-promoting layer to the non-stick layer.
3. Copolymer: Here, both precursors are mixed before entering the plasma zone and simultaneously deposited on the substrate, thereby forming a tight network.

The results

After coating, the lamination plates were brought together with polyurethane (PU) films under specific pressure and temperature and separated again for evaluation of the layers by means of peel tests.

The adjacent graph shows subtracted ATR-FTIR spectra generated by measuring the polymer films after lamination and the subsequent peel test. Following the measurement, reference spectra were subtracted from the measured spectra and peak areas were determined. Peaks in the wave number range of 1000 – 1200 cm^{-1} are attributed to the presence of Si-O bonds

1 *Security features (printed and embossed).*

2 *Composite layer systems.*

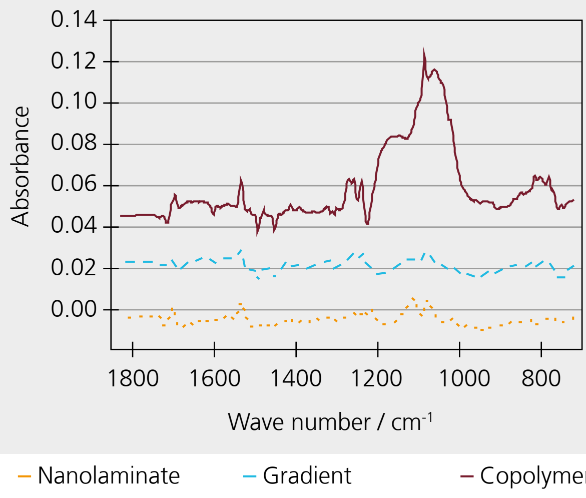
in the plasma coatings. A comparison of the peak areas of the three different coating systems showed that in the case of the copolymer, a significant amount of the coating was transferred to the polymer during the lamination process. In contrast, the spectra of the gradient and nanolaminate coatings did not show any vibration bands typical for the Si-O bond, which is considered proof that no coating transfer has occurred. Consequently, the gradient and nanolaminate coatings are fundamentally suitable for a coating between lamination plate and film.

The adjacent diagram shows the peel-off values of the sheets. The non-stick effect of the copolymer is very weak. It seems to adhere strongly on both sides, both on the lamination plate and on the laminated film. During the peel test, the coating exhibits a coherent failure due to the strong adhesion at both interfaces. In contrast, the nanolaminate yielded significantly better results than the copolymer. Here, the peel forces were only one third of those of the copolymer, but no improvement could be observed compared to the uncoated reference.

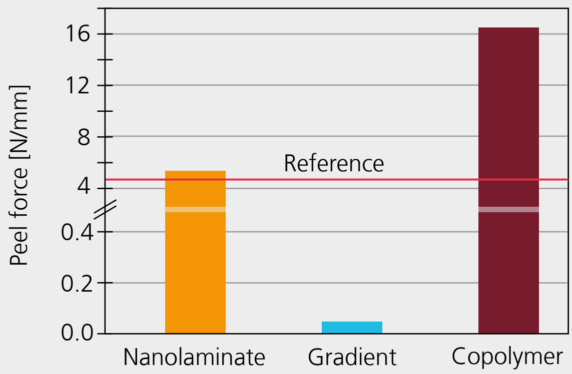
The best results in terms of the desired non-stick effect were achieved with the gradient layer. Here, the peeling force is 100 times lower than for the reference material. The laminating film more or less "falls" off the lamination plate.

Outlook

Through utilization of the new layers, it will be possible in the future – in addition to the use of further materials – to laminate the most diverse types of plastics by means of robot-assisted automated rapid lamination.



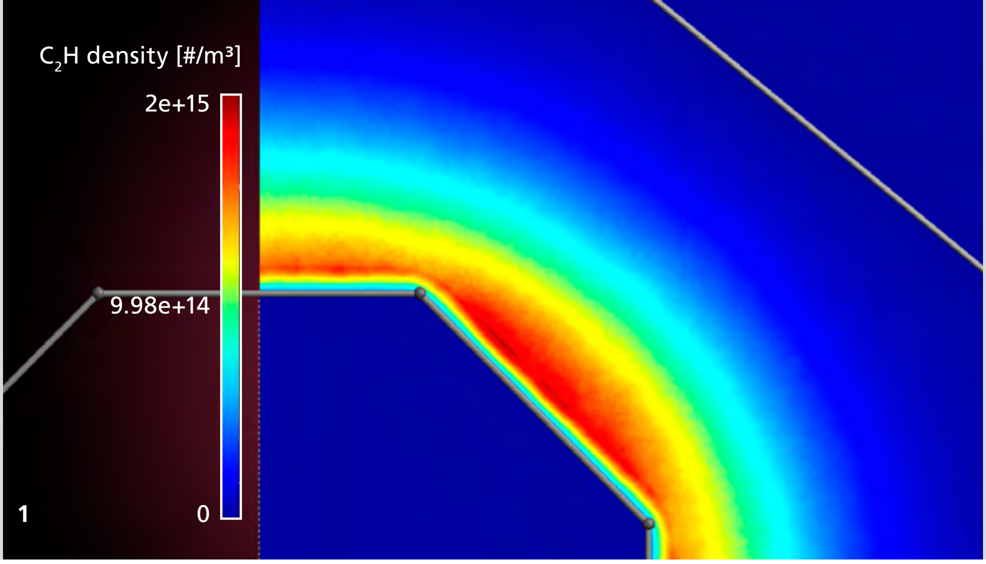
Subtraction spectra for laminated polymer films following peel test.

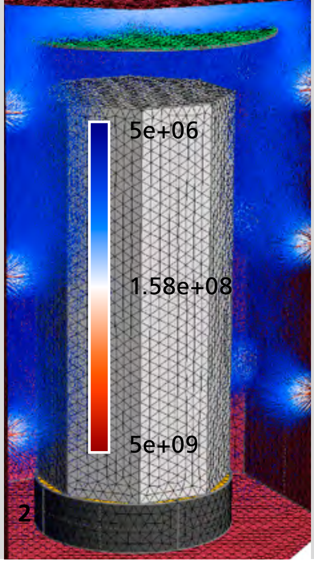


Peel forces for the composite layer systems.

CONTACT

Annika Mann, M. Sc.
Phone +49 531 2155-639
annika.mann@ist.fraunhofer.de





UPSCALING OF PECVD PROCESSES

Tribological hard-material coatings produced through PECVD processes (plasma enhanced chemical vapor deposition), in particular amorphous hydrocarbons (a-C:H or DLC, diamond-like carbon) are utilized in many technical applications. Their further proliferation and improvement, notably the enlargement of the coatable component surface, is limited however, by the complexity of the coating process. The Fraunhofer IST is therefore currently working on an in-situ ascertainment of the coating conditions in combination with a modeling of the process dynamics and layer formation, in order to enable a targeted scaling up of the process.

Amorphous hydrocarbon coatings protect against friction and wear

In many situations, DLC coatings are the method of choice for reducing friction and wear. With coefficients of friction close to those of polytetrafluoroethylene (Teflon®) and a hardness similar to that of ceramics, they are already frequently used today as a means of improving service life and increasing quality, for example in forming processes. In many cases, new processes are only made possible by DLC coatings, for example when the objective is to reduce or entirely avoid cooling lubricants in forming processes.

The challenge: Large and numerous components

DLC coatings are generally produced through PACVD processes. The vacuum plasma discharge used in this process has a complex physical behavior which, furthermore, depends strongly on the size and shape of the part to be coated. The larger and more complex the workpiece is shaped or the more small individual parts are to be coated, the more difficult it becomes to predict the necessary equipment settings in order to achieve sufficient coating homogeneity.

Larger component volumes in the form of large or numerous workpieces as well as an increasing complexity of coatable components are, however, required in order to expand the field of application and make the processes more economical. In order to overcome the resulting problem of scaling up, the Fraunhofer IST utilizes computer-aided simulation.

The solution approach: Modelling, process control and layer analysis

In the AiF Cornet project "DLCplus - Improved DLC coatings by more efficient process design", the Fraunhofer IST, in collaboration with the Université de Namur and the MateriaNova research facility in Mons, Belgium, is addressing this challenge.

By means of PIC-MC (Particle-in-cell – Monte Carlo), models of the layer-forming particle streams are created. The thereby resulting statements concerning the measurable, location-dependent plasma parameters, such as ion and neutral-particle current density and plasma potential, are verified in coating experiments using appropriate measurement technology.

The deep analysis of the actual plasma conditions on the component surface achieved in this way enables the targeted adjustment and improvement of the coatings. The feedback of the measured layer characteristics serves in turn as a means for improving the model and control variable for the coating process.

3

1 *Simulation of the density of layer-forming gas particles.*

2 *Gas-flow simulation in a modeled coating chamber.*

3 *Fully equipped PACVD coating system.*

Outlook: More efficient process management through modeling and forecasting

The aim of the described work is to develop a process-control system that significantly advances the current status of technology. Reliable predictions of the coating result should be made possible. The results and future possibilities of the coating technologies will thereby be considerably improved and expanded. In this way, virtually all fields of the forming metal industry, automotive technology, and tool and fixture construction can benefit. Higher efficiency increases productivity and reliability and reduces costs. A deeper understanding of the coating process enables better optimization and exploitation of new coating situations.

The project

The described work receives funding for the promotion of an individual research project of joint industrial research from the German Federal Budget 2018, Section 09, Chapter 0901, Title 686 01, in the variant: CORNET (as part of a transnational CORNET overall project); IGF Project No: 230 EN.

CONTACT

Dipl.-Ing. Kai Weigel, M. Sc.
Phone +49 531 2155-650
kai.weigel@ist.fraunhofer.de

Dr. Andeas Pflug
Phone +49 531 2155-629
andreas.pflug@ist.fraunhofer.de

AEROSPACE

Within this business unit, coating technologies are developed for the aerospace sector. The focus is on functionalizing lightweight materials such as carbon fiber reinforced plastics (CFRP) or light metals. In addition, coating systems are developed for optical applications, in particular for special precision filters for space missions.

Currently the Fraunhofer IST is working on the following projects:

- Electroplated metallization of CFRP components
- Development of new environment-friendly CFRP metallization methods
- Surface treatment of light metals e. g. titanium, magnesium, aluminium
- Wear-protection coatings for engines in jet aircraft
- Bearing sensor systems for condition monitoring in aircraft
- Development of surfaces for molds free from release agents
- Development of coating processes for precision lenses such as filters

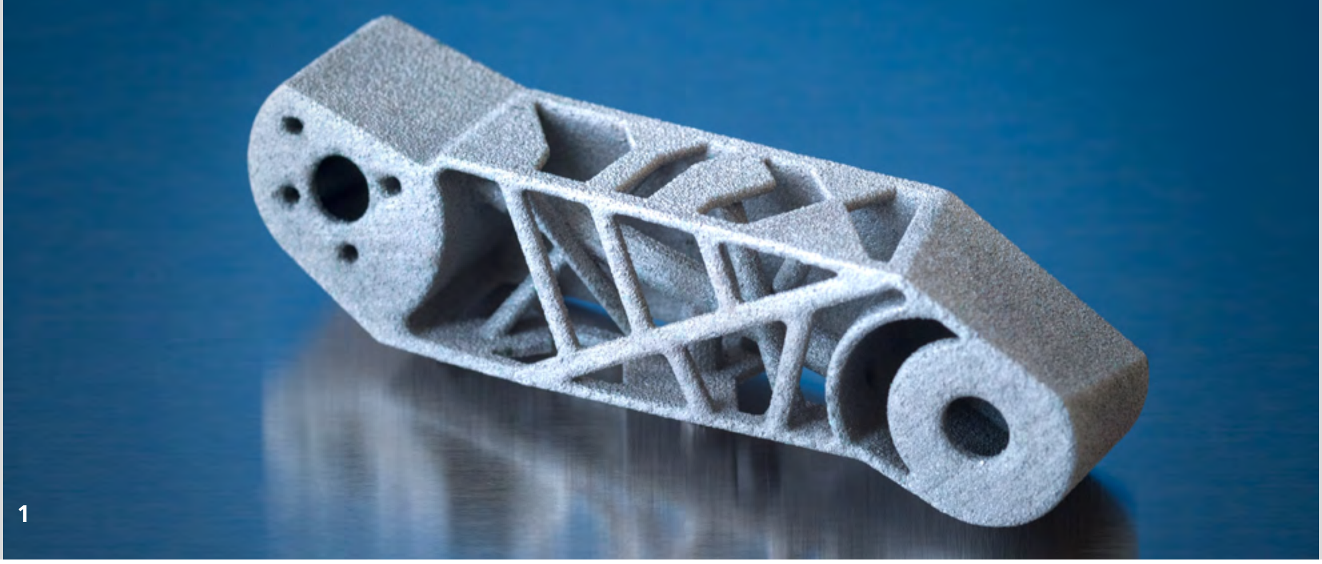
Customers include companies from the aerospace sector as well as their suppliers.

CFRP microwave reflector with a PVD and PACVD functional coating for MetOp-SG satellites.

Sustainable Development Goals per business unit

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

13 CLIMATE ACTION



1

SURFACE TECHNOLOGY FOR THE GENERATIVE PRODUCTION OF POLYMER COMPONENTS

Additive manufacturing as a production process for the manufacture of parts and components is already playing an important role today – and this role will become even more significant in the future. The design of highly complex geometries paired with the most diverse materials, such as metals, ceramics and plastics, opens up a variety of possibilities which are not possible with traditional manufacturing processes such as turning or milling. One weak point of additive manufacturing is currently presented by the surface, which can vary greatly depending on the manufacturing process. This can lead to problems in the utilization of the components and may necessitate surface treatment. At the Fraunhofer IST, additively manufactured components are therefore galvanically metallized and furnished with the desired surface properties.

Structural components in aerospace

Until now, so-called structural components, i. e. brackets, connecting pieces, etc. have been manufactured from metal using conventional processes such as turning or milling. These parts are heavy and, as a result of the manufacturing processes, not always optimal as regards design. If these components are manufactured by means of additive processes, they can be designed more advantageously, for example to save weight or to achieve improved mechanical properties. If the metal material is replaced by plastics, the weight can be reduced even further. Plastics, however, do have a number of disadvantages compared to metals; they are, for example, not conductive without an appropriate coating.

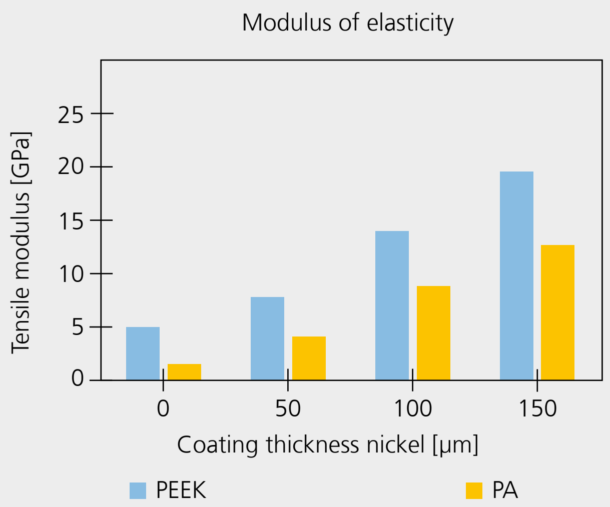
The properties of plastics

In the research project AMPFORS (Additive Manufacturing of Polymer Parts for Space), funded by DLR within the framework of the “InnoSpace Masters” program, the Fraunhofer IST, in collaboration with OHB AG in Bremen and Rauch CNC Manufaktur in Baden-Baden, is therefore investigating how the metallization of additively manufactured plastic components can improve their properties. These components are to be used in space travel and must therefore fulfill a multitude of special properties. As an example, polymers in a vacuum tend to outgas water or unreacted monomer, which can deposit on optical instruments and impair their function. The surfaces must also be conductive in order to prevent electrical charging of the parts in space.

Coating the components

Within the project, components were manufactured from the high-performance plastic polyether ether ketone (PEEK) and the construction plastic polyamide (PA) with the aid of the additive manufacturing process SLS (Selective Laser Sintering). These parts were subsequently galvanically metallized and tested at the Fraunhofer IST. A nickel coating with differing layer thicknesses of 0 – 150 µm was applied as the metal. Initial investigations have shown that the metal coatings can be firmly applied to the plastic surfaces. The adhesion test ECSS-Q-ST-70-17C, a thermal-shock test important for space applications, was successfully executed. It could also be shown that the mechanical properties are dramatically improved through metallization. The modulus of elasticity for uncoated

1 – 2 *Metallized structural components made from PEEK.*



Rising modulus of elasticity for coated polymers (PEEK and PA) with increasing coating thickness.

PEEK, for example, increases from 4.8 GPa to 20 GPa with a coating thickness of 150 µm nickel on the plastic. The situation is similar with polyamide, where the modulus of elasticity increases from 1.5 GPa to 12.5 GPa (see opposite figure). The flexural and compression moduli increase accordingly.

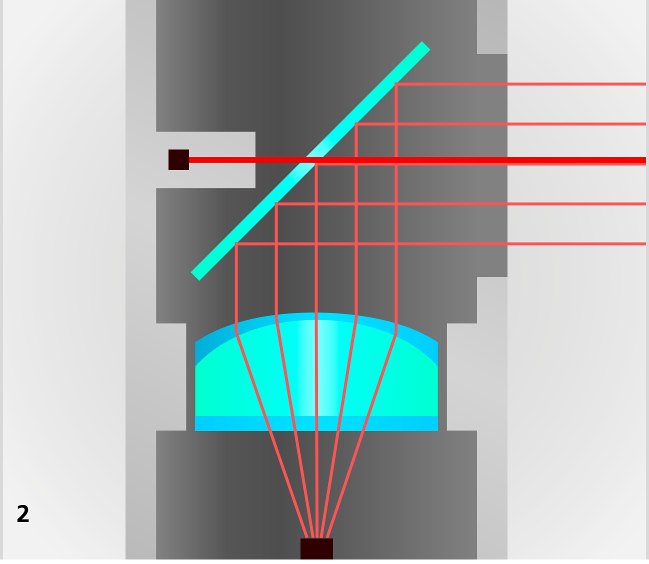
Outlook

Within the further scope of the project, the extent to which the possible geometry optimization impairs the metallization must be clarified. Galvanic processes suffer from the fact that complex geometric structures can only be metallized to a limited extent as a result of the necessary electric field often being shielded. Chemical metallization processes can be the solution.

CONTACT

Dr. Andreas Dietz
Phone +49 531 2155-646
andreas.dietz@ist.fraunhofer.de

1



2

NARROW IR BANDPASS FILTER ON THREE-DIMENSIONAL SURFACES

So-called LIDAR (light detection and ranging) systems for distance measurement play an important role not only in the automotive industry, e. g. for autonomous driving, but are also essential in the aerospace industry. Here they provide the data required for a space capsule to dock precisely with a satellite station. In order to prevent errors caused by interfering light, e. g. from the sun, a narrow-band infrared bandpass filter (IR bandpass filter) with wide blocking is placed in front of the actual optics. The aim is the development of more compact and, above all, lighter systems in the future. The Fraunhofer IST is providing a building block for this purpose through the development of a process which will enable the direct deposition of a bandpass filter on the lens.

The challenge

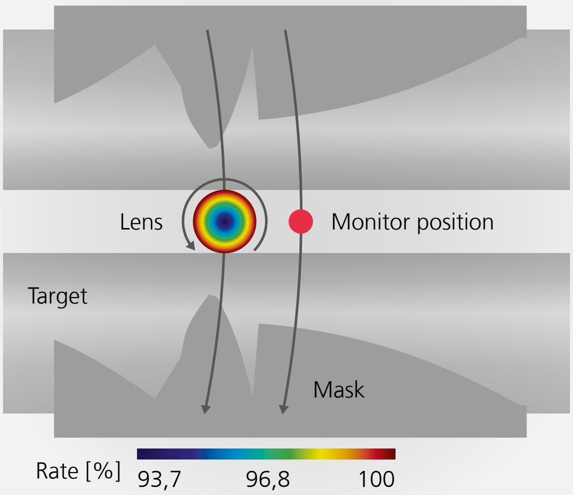
For the production of narrow IR bandpass filters with wide blocking, a complex system consisting of a multitude of individual layers is deposited with high precision in the EOSS® sputtering system at the Fraunhofer IST. Deposition on three-dimensional surfaces such as aspherical lenses thereby poses a major technical challenge, as the coating rate depends heavily on the distance and angle of the coating surface relative to the coating source.

Without corrective measures, this results in the coating of a plano-convex lens being thicker in its center than at the edges. Furthermore, the angle of incidence also changes depending on the position on the lens. Both effects – the decreasing layer thickness towards the edge of the lens and the increasing angle of incidence – intensify each other mutually and shift the bandpass to smaller wavelengths (see figure 2).

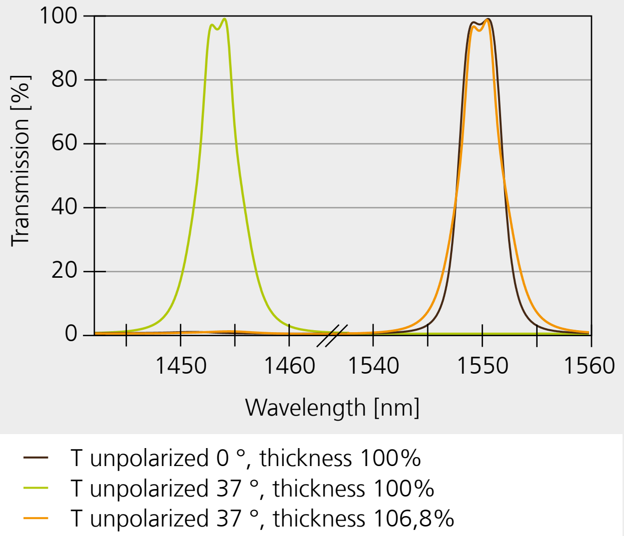
The Fraunhofer IST solution

In order to compensate for both negative effects, a homogeneous coating of the three-dimensional surface alone – e.g. by means of the ALD process (atomic layer deposition) – is not sufficient. For an ideal compensation, a layer thickness gradient is necessary in which the thickness towards the edge of the lens increases in such a way that the shifting of the bandpass is also corrected through the increasing angle of incidence. For this purpose, a process was developed at the Fraunhofer IST with which the optical filters can be precisely deposited on a plane/convex aspherical lens with a diameter of 50 mm by means of magnetron sputtering.

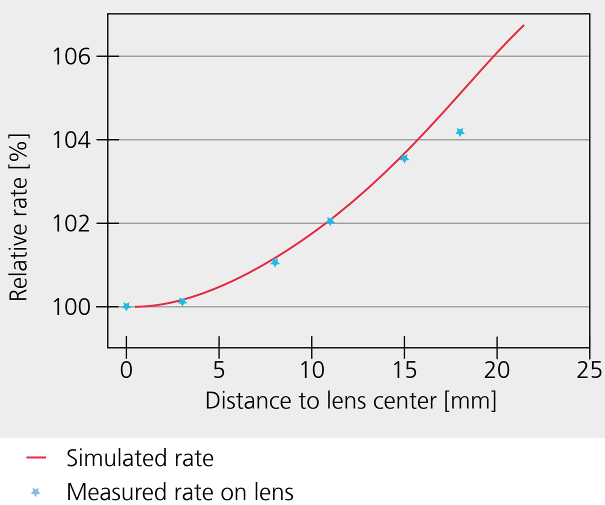
The central wavelength of the bandpass lies at 1550 nm. For the suppression of interfering light, the filter should exhibit blocking from 400 to 1800 nm. This very wide blocking of the filter system is achieved with two differing layer designs: Firstly, the plane rear side of the lens is homogeneously coated with a blocker in the form of a longpass, and secondly, a bandpass with a gradient aperture is precisely deposited on the convex side. The necessary layer thickness gradient on the lens is achieved by rotating the substrate and using a suitable aperture. As a result of a specially adapted layer design, the bandpass remains virtually unchanged, even at the maximum angle of incidence of 37° (see adjacent upper graphic). The aperture shape was optimized with the help of a digital twin of the coating process in the EOSS® system and it was possible to adopt this into the real system without any further adjustments.



3



Transmission of a modified bandpass for the angles of incidence of 0° and 37° with an unpolarized light beam. The transmission spectrum for an angle of incidence of 0° is shown for a thickness of 100 %. The transmission spectra for an angle of incidence of 37° are shown for a thickness of 100 % and 106.8 %.



Measured and simulated relative rate of tantalum pentoxide in relation to the center of the lens. For an optimal layer thickness gradient, the lens must be rotated on an orbit with a radius of 545 mm.

1 *Coated aspherical plane/convex lenses.*

2 *Schematic diagram of a LIDAR system.*

3 *Representation of the silicon dioxide lens masks, the lenses and the monitor substrate with the respective rate profiles on the surfaces. In the illustration, the targets, the main rotation of the system and the sub-rotation of the lenses are marked.*

Outlook

Following the successful development of the process, plans have been made to deposit the complete narrow IR bandpass filter with wide blocking onto the lens and to test it in the LIDAR system.

The project

The narrow IR bandpass filter on a plano-convex aspherical lens with a diameter of 50 mm for a LIDAR application was developed within the framework of the BMBF research project "EPIC Lens" (FKZ 13N14583).

CONTACT

Chris Britze, M. Sc.
Phone +49 531 2155-516
chris.britze@ist.fraunhofer.de

ENERGY AND ELECTRONICS

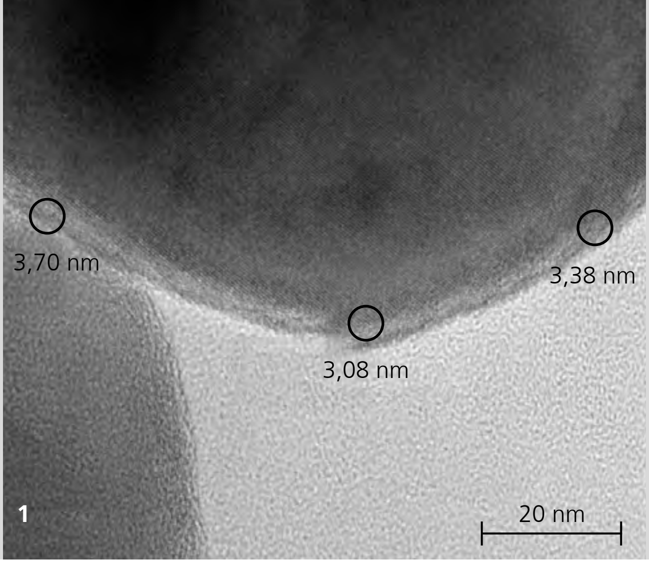
In the business unit "Energy and electronics" the work of the institute concentrates on the following developments:

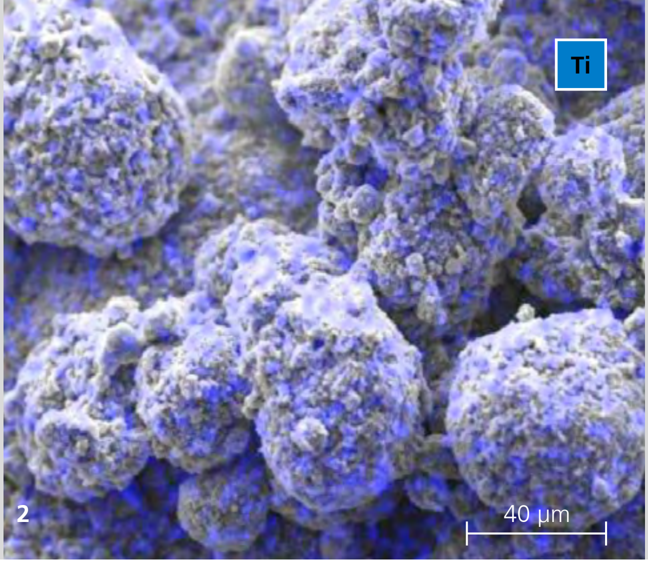
- Functional coatings or coating systems and coating processes for architectural glass (low-E-coatings, active or passive heat and sun protection, switchable electrochromic glazing)
- Transparent conductive coating systems (TCOs) for architectural and automotive glazing, for solar cells, displays and invisible heating elements and also for solar thermal energy
- p- and n-type TCOs as materials for transparent and flexible electronics
- Semiconductor layers for thin-film and silicon-based photovoltaics and also characterization methods for thin-film solar cells
- Electrical contact and insulating layers, as well as barrier layers
- (Local) plasma treatment of surfaces for wafer bonding, structured metallization and metallization of temperature-sensitive and complexly shaped substrates
- Stable anodes and cathodes for lithium-ion batteries
- Electrolytic coatings for high-temperature fuel cells (SOFC) and gas separation membranes for hydrogen production
- Corrosion-protection and thermal-barrier coatings for high-temperature applications, such as in gas turbines

Our customers include companies in the glass, photovoltaics and automotive industries, in semiconductors and microelectronics, in the information and communications sectors, in the energy and construction industries, and also plant manufacturers and contract coating companies.

Sustainable Development Goals per business unit

Electrodes for the production of battery cells.





FIELDS OF APPLICATION FOR ATOMIC LAYER DEPOSITION

Homogeneous and nanometer-precise coatings are playing an increasingly important role in numerous fields of application, such as in the manufacture of fuel cells, lithium-ion batteries and corrosion-resistant coatings for automotive parts. For this reason, the Fraunhofer IST has long been successfully developing ALD processes with which such coatings can be produced. In a joint project with the Institute for Particle Technology at the TU Braunschweig, the Fraunhofer IST has, amongst other things, utilized atomic layer deposition to selectively functionalize battery materials.

The technology

Atomic layer deposition (ALD) is a modified process of chemical vapor deposition. The characteristics of the process are two successive self-limiting surface reactions which allow the deposition of extremely thin, defect-free and exceptionally homogeneous layers. These advantages of ALD technology are increasingly being exploited in other industries, such as battery technology.

Current challenges in battery technology

Current challenges in battery technology are, firstly, to optimize the manufacturing processes of lithium-ion batteries and, secondly, to develop appropriate processes for new types of energy storage technologies such as all-solid-state batteries (ASSB). In both cases, material, process and production parameters must correlate with the electrochemical performance, i.e. the desired performance characteristics of the batteries. All steps of the entire process chain ultimately influence the product properties: material production and assembly as well as mixing and dispersing, the extrusion of electrode suspensions, and coating and calendering. A decisive factor is thereby presented by the interfaces between the deployed materials and components. Depending on the cell chemistry, these interfaces are subjected to differing requirements. A targeted functionalization of the surfaces by means of atomic layer deposition allows a corresponding adaptation.

One example is the coating of composite materials by means of ALD as shown in Figure 1. Through the coating, it was possible to improve the flow properties of the granulates under the given conditions, thereby simplifying the processability. Furthermore, the coating material has a positive effect on the resulting cell properties.

1 *TEM image of the TiO_2-coated composite material.*

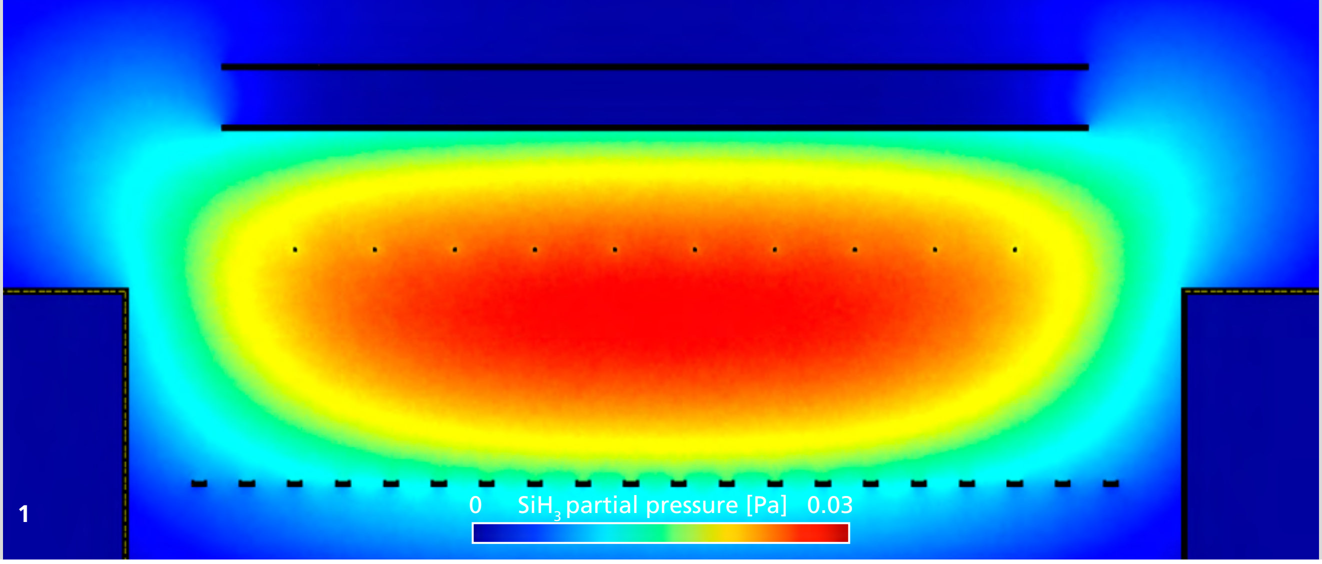
2 *REM-EDX of 5 cycles TiO_2 at 70 °C (blue - Ti).*

ALD in battery technology

The fields of application for ALD in battery technology range from the functionalization of particulate materials such as active materials and granulates through to layer structures such as electrodes. Through the targeted application of functionalities, various effects can be achieved, such as the reduction of interfacial resistances, the improvement of the chemical resistance, and enhanced adhesion properties.

CONTACT

Tobias Graumann, PMP
Phone +49 531 2155-780
tobias.graumann@ist.fraunhofer.de



DIRECT SIMULATION MONTE CARLO OF HWCVD SILICON DEPOSITION PROCESSES

Hot-Wire Chemical Vapor Deposition (HWCVD) processes provide the possibility to produce both amorphous and nano-crystalline doped and intrinsic silicon films with high rates up to 2 nm/s over large surface areas up to 800 x 665 mm^2. These processes have advantages to other deposition methods in that the film stress is significantly lower than with other technologies due to the absence of ion bombardment. However, the optimization of these processes can be a significant undertaking due to the relative complexity of the deposition. At Fraunhofer IST a full gas-phase and surface deposition simulation model of HWCVD silicon deposition processes, including silane (SiH_4) and hydrogen (H_2), was created as a tool to optimize film properties.

Simulation software

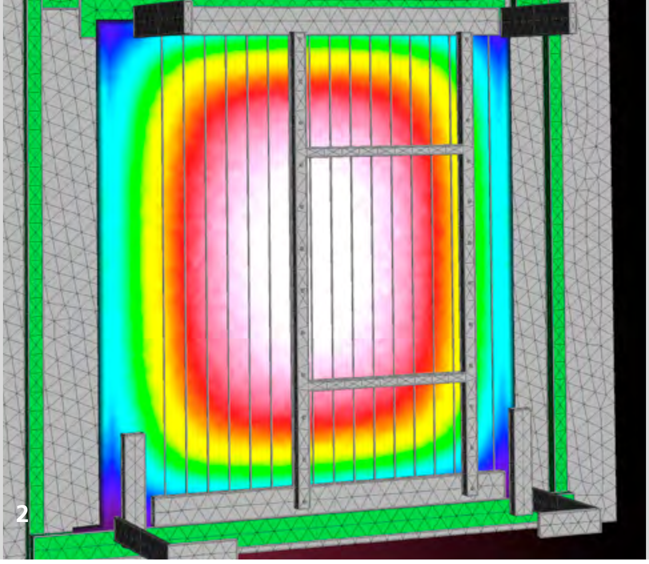
At the Fraunhofer IST the simulation group performs simulations of physical vapor deposition (PVD) and plasma processes using self-created software based on the Direct Simulation Monte Carlo (DSMC) method. Aiming for an increased understanding of silicon deposition processes, the HWCVD group partnered with the simulation group to develop an advanced simulation model of various HWCVD based silicon deposition processes.

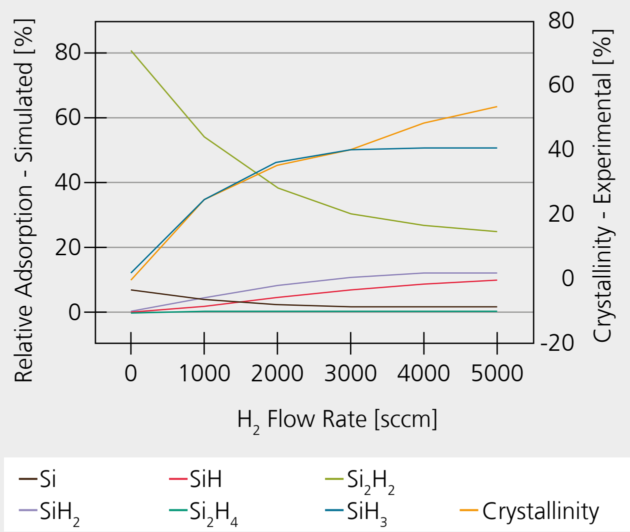
Using the DSMC framework, this model was created with the goal to investigate how process parameters influence the structure of the as-deposited amorphous and nano-crystalline films. This new model implements both silane and hydrogen process gases, with hydrogen being used in deposition to influence the crystallinity of the resulting film. In addition, all major gas-phase and surface interactions of Si-species created during the deposition process were implemented in order to simulate how changing process parameters affect the concentration of specific gas-phase species, in addition to changes in surface-adsorption rates of these species.

Simulation confirmation and results

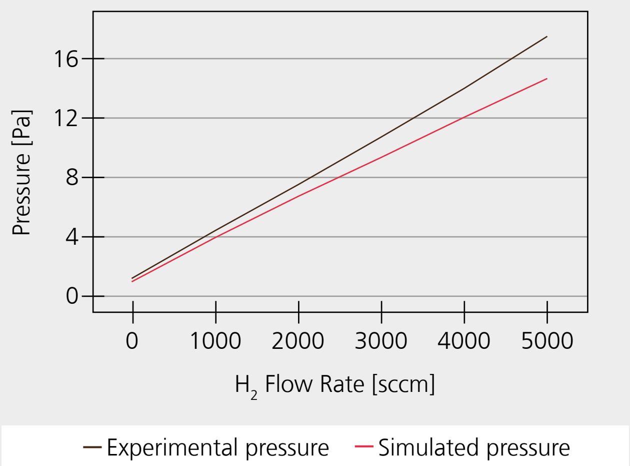
The new model is validated by an experimental parameter study. Measured data include deposition pressure, deposition rate (both film thickness and film mass deposition rates), in addition to mass-spectrometry measurements of silane utilization. After all simulated values agreed closely to the measured data, a series of simulation runs were made in order to simulate the effect of increasing hydrogen flow rate on the relative adsorption of specific silane species at the substrate position, in addition to the effect on the concentration of all major silane species in the gas phase.

The results of the simulation series confirm previous theory, which suggests that higher mobility species such as SiH_3 and Si_2H_4 lead to more crystalline films, whereas lower mobility species such as SiH, SiH_2, and Si_2H_2 lead to amorphous film growth. In addition, these results are confirmed by accordant experiments. Experimentally, an increase in either pressure or hydrogen flow leads to an increase in the resulting crystallinity of the film, where the simulation also shows a corresponding increase in SiH_3 and decrease in Si_2H_2 availability.





Simulated species adsorption at substrate as function of hydrogen.



Simulated partial pressure of SiH_3 species under steady-state process conditions.

1 *Simulated partial pressure of SiH_3 species under steady-state process conditions.*

2 *3D HWCVD chamber geometry used by Pflug et al.*

Outlook

This work provides many possibilities for process improvement in the field of silicon deposition by means of HWCVD, without the need for significant time and financial investment for wide-scoped test plans. With additional planned improvement involving the implementation of hydrogen-based surface etching reactions during the deposition process, the implementation of both phosphor and boron-based dopants, as well as an increase to surface-deposition model complexity, this model can provide even further insights into production-scale silicon deposition processes.

The project

This project was supported by the Fraunhofer Internal Programs under Grant No. MAVO 831 409.

CONTACT

Hunter King
Phone +49 531 2155-641
hunter.king@ist.fraunhofer.de

Dr. Volker Sittinger
Phone +49 531 2155-512
volker.sittinger@ist.fraunhofer.de

OPTICS

In its business unit "Optics" the Fraunhofer IST is active with a variety of thin-film technologies developing new solutions for new industrial applications. These include:

- The development and manufacturing of coatings for optical components
- Systems for the deposition of high-grade optical coatings on flat and curved lenses
- The EOSS® production platform for manufacturing optical filters and laser components
- The development of new materials for intelligent coatings, such as electrically switchable filters
- Highly durable broadband anti-reflective coatings on sapphire and glass
- Micro-structured optical filter coatings for imaging applications
- Optical coatings on plastic surfaces
- Use of simulation in designing and optimizing coating processes and installations in low-pressure systems
- Development of innovative transparent conductive coatings for lighting technology and oxide electronics

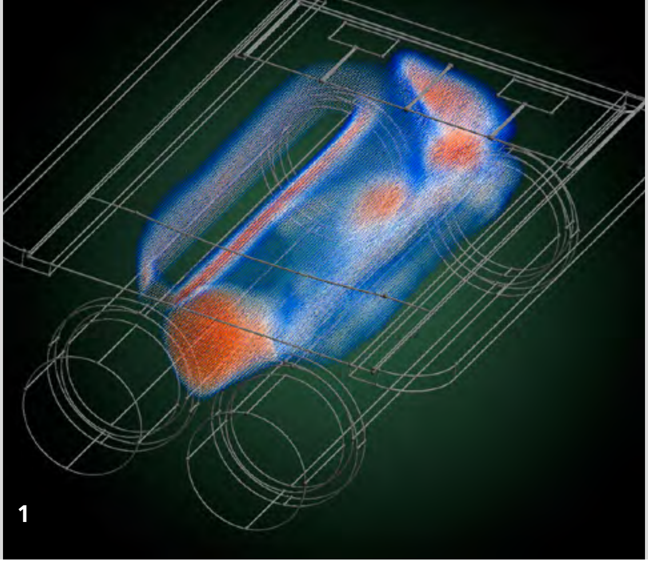
In the field optical metrology the Fraunhofer IST focuses on the following topics:

- In-situ monitoring of coating processes with MOCCA+®
- Mapping system for measurement of ellipsometry, reflection, transmission, flare and Raman spectroscopy on 60 x 60 cm^2
- Defect analysis of optical layers by means of FIB REM and confocal optical microscopy
- Testing the wear and corrosion resistance of optical surfaces and coatings

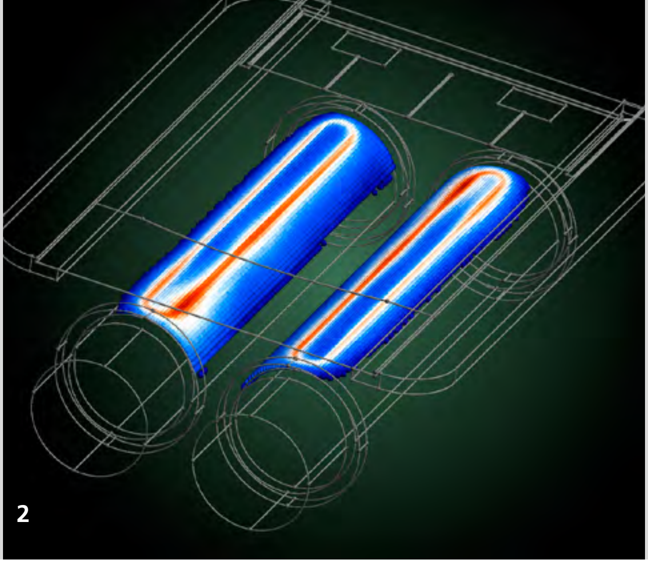
This business unit includes clients from companies in the optical industry, the automotive industry, aerospace, manufacturers of displays and data storage media as well as plant manufacturers and contract coating companies.

Black coating with dielectric beam splitter layer for use in space applications, e.g. in spectrometers.

Sustainable Development Goals per business unit



1



2

SIMULATION OF OPTICAL PRECISION COATINGS ON CURVED COMPONENTS

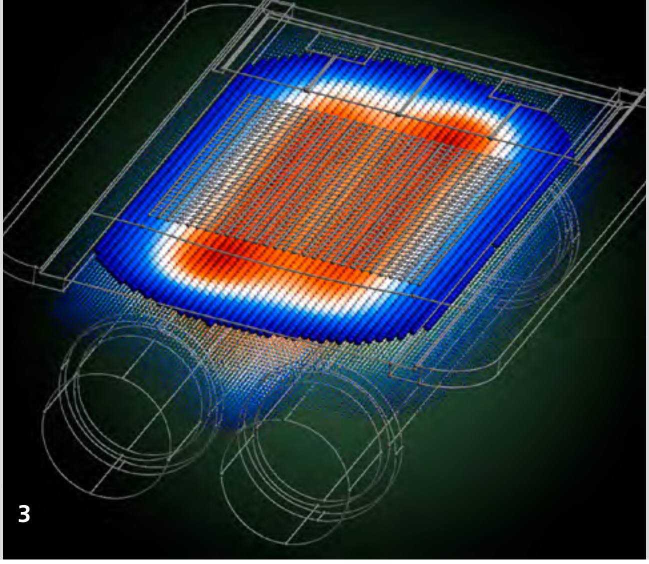
In the manufacture of optical components, it is advantageous to apply the required optical filter systems directly onto the curved surfaces of e. g. lenses instead of using separate flat substrates. This minimizes the quantity of components and internal reflections. However, the variable angle of incidence on curved surfaces leads to spectral shifts. In order to compensate for this, the optical filters must be applied with a defined layer-thickness profile. In the case of a convex lens, for example, this means that the layer-thickness must increase from the center towards the edge. In contrast, in PVD processes such as magnetron sputtering, a reversed layer-thickness profile usually occurs on convex surfaces. A digital twin, based on data from a previous multi-scale process simulation performed at the Fraunhofer IST, enables the iterative optimization of shaper masks in order to solve this coating problem.

The solution approach

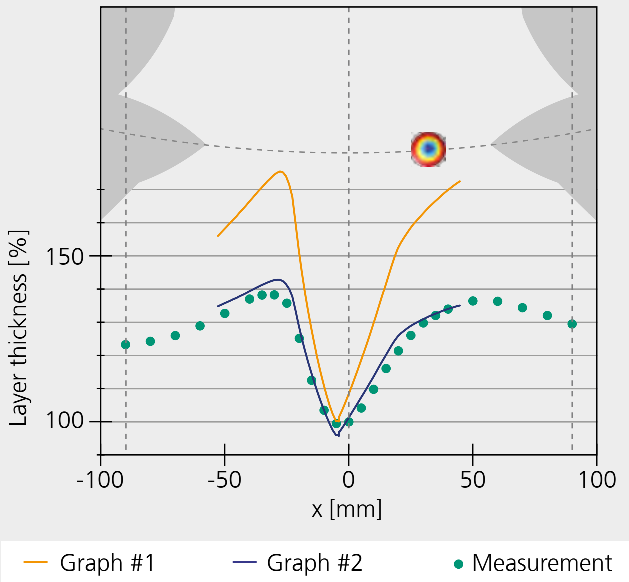
The coating process was realized on the EOSS® sputtering facility at the Fraunhofer IST. This system consists of two sputter compartments with dual cylindrical cathodes which are sputtered in argon, above which a fast-rotating turn table is mounted to which the substrates are attached. In an additional RF plasma source, the complete oxidation of the sub-layers takes place in an oxygen plasma. For rotationally symmetric 3D substrates, a special sample holder with built-in sub-rotation is utilized, whereby the layer-thickness profile is adjusted through special shaper masks at the compartment edges.

The multi-scale simulation model is used to specify the design of the shaper masks. The plasma, as well as the gas flow and transport of the sputtered particles, can be simulated using a kinetic software developed at the Fraunhofer IST in which the "Direct Simulation Monte-Carlo" (DSMC) and "Particle-in-Cell Monte-Carlo" (PIC-MC) methods are combined. Two practical problems thereby are the computational effort – approx. one day for DSMC and several days for PIC-MC – and the fact that the layer-thickness profile on moving substrates results from the addition of many sub-profiles from different positions. With the previous methods, this procedure is therefore considerably too time-consuming.

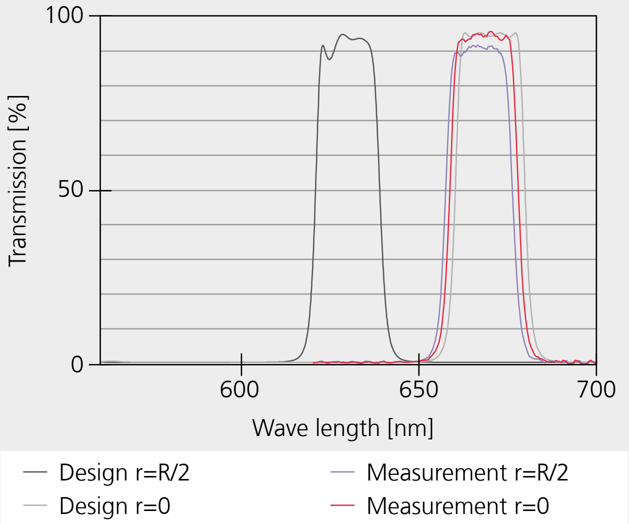
With a multi-scale approach, these problems are solved as follows: Firstly, the plasma and the sputter erosion profile at the target are determined using the PIC-MC method (see Figs. 1, 2). This information is subsequently used to simulate the transport and scattering of sputtered particles (see Fig. 3). The angle-resolved particle flow is thereby recorded in a plane a few millimeters below the substrates with a spatial resolution of 10 x 10 mm^2. Using this plane as a "virtual particle source", the remaining particle transport up to the substrate is subsequently calculated using a simple ray-tracing approach, during which the shaper mask can simultaneously be taken into account in parameterized form. This approach is possible as the remaining distance lies below the mean free path and the scattering of the gas can therefore be neglected. The ray-tracing algorithm enables the calculation of a complete motion trajectory within a few seconds on a single CPU and can therefore be regarded as a "digital twin" for the coating process on 3D substrates.



3



4. Shaper mask with lens trajectory, below this the measured and calculated layer-thickness profile on flat substrate.



5. Realized coating on lens and measured spectra of a bandpass filter.

1–3 *Simulation of the plasma discharge (1), the target erosion profile (2) and the particle transport (3) during magnetron sputtering.*

Validation of the simulation model

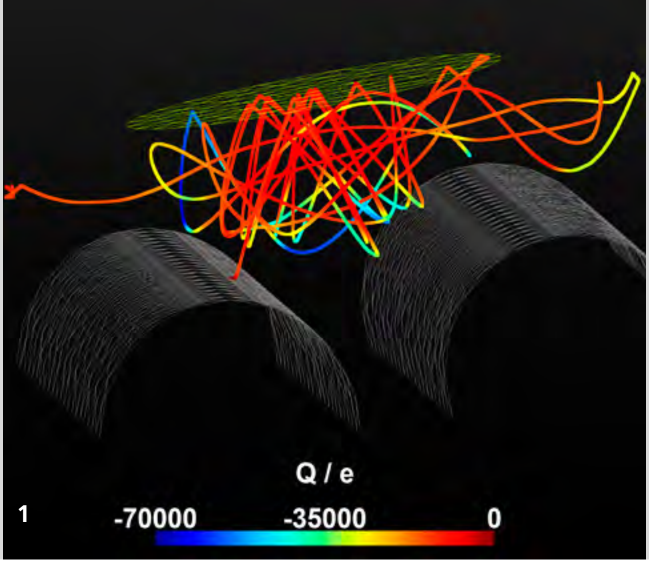
A bandpass filter was deposited on a plano-convex spherical lens with a diameter of 20 mm and a curvature radius of 25 mm. In order to compensate for the spectral shift, a layer-thickness increase of 3.5 % from the center to the edge is required. The shaper mask geometry obtained through iterative optimization has a characteristic spiky form whose center point coincides with the lens trajectory (see Fig. 4, above). To test the model, the layer-thickness profile was first measured on non-rotating flat substrates (Fig. 4, below). It hereby could be determined that the assumption of a homogeneous target-erosion profile is insufficient (Graph #1); good correlation can only be achieved with the sputter profile from the plasma simulation (Graph #2). The bandpass coating was realized with an appropriate shaper mask and a rotating substrate holder. As can be seen in Figure 5, the spectral shift of the filter across the lens surface could be largely eliminated with the aid of the numerically optimized shaper mask.

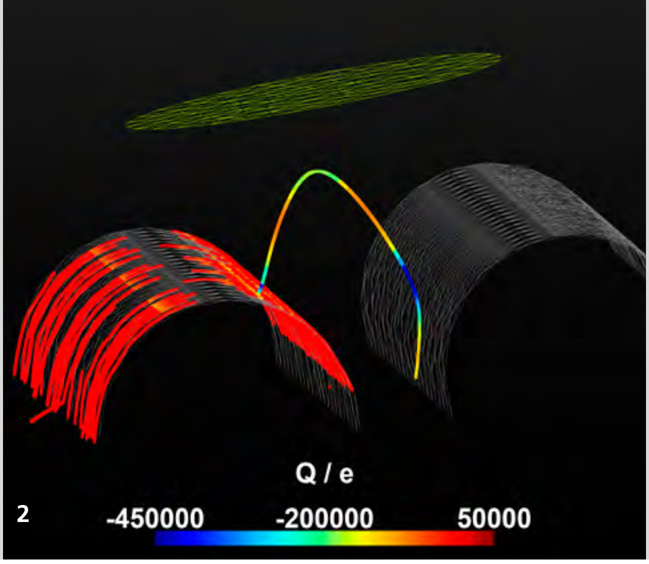
Outlook

The digital twin of the coating process on the EOSS® sputtering facility has been successfully validated and will be utilized for further process and substrate geometries in the future.

CONTACT

Dr. Andreas Pflug
Phone +49 531 2155-629
andreas.pflug@ist.fraunhofer.de





PARTICLES IN COATING PROCESSES

In optical coatings, particles may manifest as layer defects, compromising the image quality, performance compatibility and longevity of the optics, particularly in the short-wave spectral range or in laser applications. The reduction of defects in coatings is therefore one of the most important goals of modern coating technologies. Within the framework of the "EVAPORE" project, mechanisms which can lead to the formation of particles were investigated. In order to better comprehend the behavior of dust particles in coating processes, the Fraunhofer IST had developed a program which is capable of simulating the movement and charging of dust particles, resulting in the simulation software PALADIN – Plasma Lattice Dust Integrator.

PALADIN – Plasma lattice dust integrator

The PALADIN software is able to simulate the movement of particles in any chosen three-dimensional geometry. Grid-arranged results from a previously performed plasma simulation, also developed at the Fraunhofer IST, are thereby used in order to calculate the forces and currents acting on the particles based on a physical model. Furthermore, collisions of the particles as well as their adhesion in dependence of the geometry are calculated and recorded.

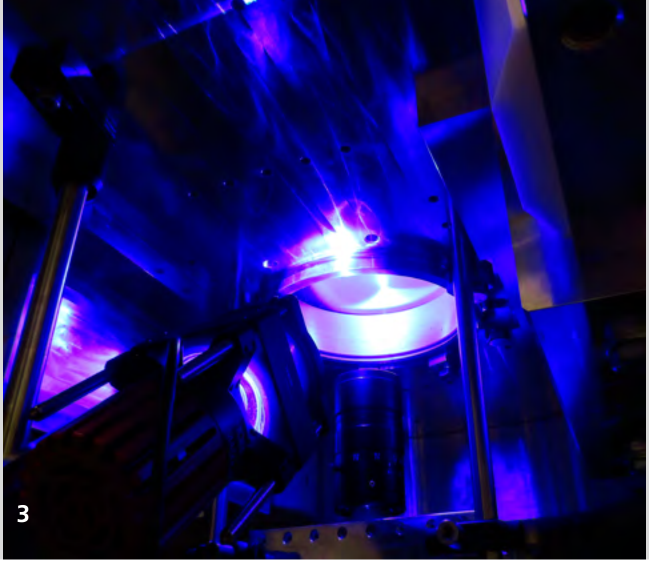
By simulating a large number of particles, statistics can be generated, e. g. concerning the acting forces or the size distribution of the particles adhering to the substrate. In addition, the path of the particles can, in principle, be reconstructed back to their origin; this makes it possible to determine where most of the particles impairing a surface actually come from.

Investigations for an avoidance strategy

Within the scope of the project, a multitude of influencing factors were examined with regard to their impact on particle pollution during the coating process. The aim was the development of strategies for the avoidance of particles. For this purpose, various process parameters, such as process pressure, gas flow, discharge power and pulse frequency, as well as the influence of the target material and the manufacturing method, were tested experimentally. The alteration of the target-substrate distance and a variation of the magnetic field during magnetron sputtering also formed a part of the investigations.

The results

The correlation between the frequency of occurrence of so-called "arcs", i. e. arc discharges, and the particle pollution in the coating process has proven to relatively clear. Such arcs usually occur in areas in which insulating layers form and a high electric field strength is present. Furthermore, the results showed that silicon-based particles – the standard material for low-refractive layers – cause a higher particle pollution than typical high-refractive materials such as tantalum pentoxide. The most plausible reason for this is the lower mass of the Si atoms compared to other materials, such as tantalum (Ta) or niobium (Nb). FIB-REM analyses on selected samples support these results. It was also observed that the magnetic field of the cathodes appears to have an influence on the formation of particles.



1 *Illustration of the development of the charge Q of a particle in PALADIN. Visible are the targets (gray, center) and the substrate (yellow, top) of the EOSS®.*

2 *Charge evolution of 100 particles with 10 µm radius. Only one particle could lift off noticeably from the target.*

3 *Particle monitor on the EOSS®.*

Outlook

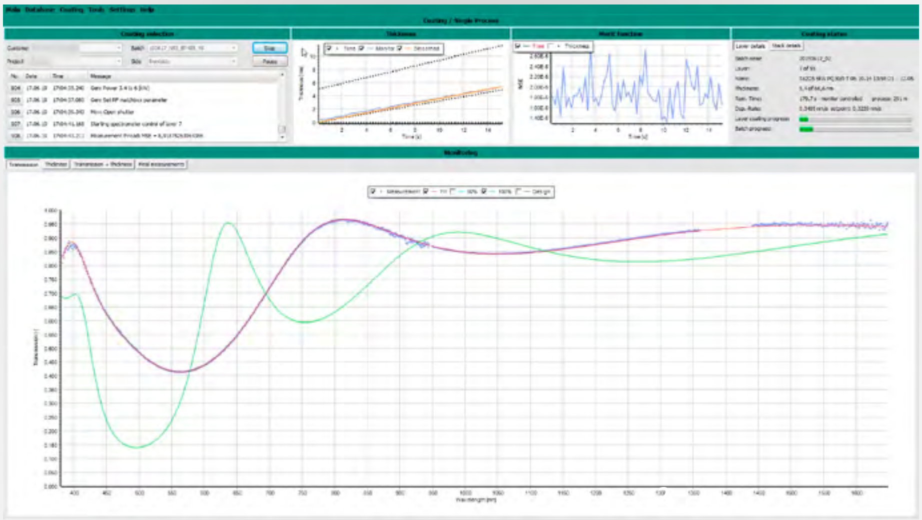
In the future, further investigations should expand the database, thereby providing better possibilities for statistical statements concerning the various influencing factors in the coating process with regard to their relevance for particle pollution as well as enabling a deeper understanding of particle formation. The aim is a continuous improvement of the coating process and thereby a minimization of the defect density.

The project

"EVAPORE – Entstehungsdetektion und Vermeidungsstrategien von Mikropartikeln in Plasmabeschichtungsprozessen für die optische Industrie" (EVAPORE – Origin-Detection and Avoidance Strategies for Microparticles in Plasma Coating Processes for the Optical Industry) is an IGF project (funding number 18590 N) of the Forschungsvereinigung Feinmechanik, Optik und Medizintechnik e. V. (Research association for precision mechanics, optics and medical technology).

CONTACT

Dipl.-Ing. Hans-Ulrich Kricheldorf
Phone +49 531 2155-952
ulrich.kricheldorf@ist.fraunhofer.de



1

NEW POSSIBILITIES WITH MOCCA+®

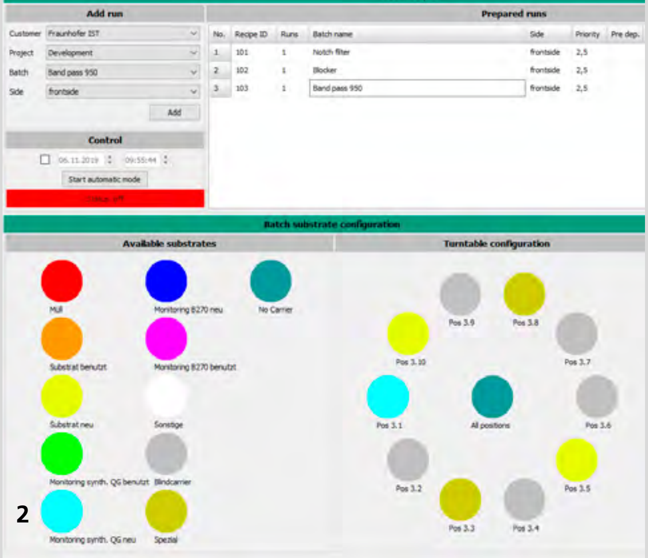
The complexity of industry-relevant optical filter systems, e. g. in telecommunications, is increasing continuously. In addition, users expect an even higher degree of equipment automation. The MOCCA+® (Modular Optical Coating Control Application) software developed at the Fraunhofer IST is, in addition to the optical broadband monitoring of the individual layers of a filter, also capable of controlling the EOSS® (Enhanced Optical Sputtering System) facility. Between the individual coating operations, it is no longer necessary for the user to intervene, as the exchange of the substrates is an automated process.

Pre-coating

With the EOSS® facility, which was also developed at the Fraunhofer IST, up to ten substrates can be coated simultaneously. Generally, one of the ten substrates is the so-called monitor substrate, through which the progression of the coating process is monitored with the aid of the MOCCA+® software. Special filter designs often require a pre-coating of the monitor substrate. This is necessary, for example, when the design begins with a low-refractive or very thin layer. The difference in refractive index between the monitor substrate and the low-refractive layer is then insufficient for optical monitoring of the deposition. For this reason, the customer substrates are not brought into the coating chamber until the pre-coating has been completed. The exchange of the substrates is determined prior to the start of the process and takes place automatically.

Parallel recipe steps

Current filter designs sometimes consist of several hundred individual layers. Between two layers, specific respective recipe steps are performed, e. g. alteration of the generator power in preparation for the next layer. With the large number of layers, even short waiting times of a few seconds accumulate to a value in the hourly range which is no longer negligible. For this reason, it is possible to execute recipe steps for the next layer whilst the current layer operation is still running. This shortens waiting times and increases the productivity of the entire system.



2

1 *Program surface during a coating operation.*

2 *User interface for definition of the substrate assignment.*

Re-design/Re-optimization

Optimization of the entire coating can be achieved through the utilization of the external programs OptiLayer and OptiRE. The calling of the applications and the evaluation of the results are also fully automated processes. With the aid of OptiLayer, the layers of a filter which have not yet been deposited can be adapted in order to compensate for process-related fluctuations. OptiRE allows the correction of the layer thicknesses of the already deposited layers, taking into consideration all the final measurements of these layers.

CONTACT

Thomas Melzig, M. Sc.
Phone +49 531 2155-644
thomas.melzig@ist.fraunhofer.de

LIFE SCIENCE AND ECOLOGY

In the field of "Life science and ecology" the Fraunhofer IST develops coatings, processes and equipment for a range of application fields:

Cell culture technology and microbiology

- Control of cell adhesion and differentiation
- Control of protein adsorption
- Coupling of antibodies
- Cell transfection and poration
- Medical technology
- Microfluidics
- Biosensors
- Lab-on-a-chip
- Implants
- Sterilization of surfaces and disinfection
- Coating and functionalization of medical disposable articles

Agricultural and food technology

- Disinfection
- Disinfection of packaging
- Barrier coatings
- Anti-adhesive coatings

Water and air purification technology

- Water disinfection and wastewater treatment by means of diamond electrodes
- Photocatalytic air and water purification systems

Self-cleaning

- Standardized test procedures for the neutral evaluation of photocatalytic properties of products

Textile technology

- Halogen-free flame protection for textiles

In addition to users in the fields mentioned, our customers also include manufacturers of equipment for surface modification and coating as well as contract coating companies at home and abroad.

"Laboratory in a bag" for the cultivation of stem cells.

Sustainable Development Goals per business unit

1

2

SAFE WATER FOR RURAL AREAS IN SOUTHERN AFRICA

In the 16 sub-Saharan African countries falling under the umbrella of the Southern Africa Development Community (SADC), more than 100 million people have no access to safe water. Most heavily affected are people in rural areas or informal settlements without connection to piped water, and unreliable or no energy supply by the grid. Water used for drinking and sanitary purposes is often significantly polluted by germs as well as organic and/or inorganic pollutants. One key cause for this lack of access to clean water is a lack of infrastructure. Rural water treatment plants are often in poor condition due to insufficient operation and maintenance. In addition, existing water purification solutions often cannot cope with the variety of contaminants introduced into the water by increasing human activities. In the EU-funded Horizon 2020 project Self-Sustaining Cleaning Technology for Safe Water Supply and Management in Rural African Areas, with the acronym SafeWaterAfrica, a European-African consortium under the coordination of the Fraunhofer IST has developed a "Made in Africa" solution seeking to fill this gap

Europe and Africa – equal partners

European and African partners have been closely cooperating in the SafeWaterAfrica project as equal partners on all levels, including technical development, training and business development, in order to develop and convey the water purification system as a "Made in Africa" solution. A "Made in Africa" perception will be of key importance in gaining acceptance of the SafeWaterAfrica technology in the African local rural communities and will promote local ownership.

SafeWaterAfrica – the technology

Core component of the SafeWaterAfrica water purification system is an electrochemical oxidation process using metal electrodes coated with a conductive boron-doped diamond layer which is only a few micrometers in thickness. With the help of these electrodes, contaminants such as pesticides, pharmaceuticals and germs are efficiently removed from polluted waters. With low voltage applied, the electrodes produce strong oxidants such as hydroxyl radicals (OH•) and ozone (O_3) which are able to deactivate viruses and to break down organic substances into safe substances.

The modular purification system has a pre-treatment including a newly developed and highly efficient electrocoagulation and electrodialysis. The pre-treatment removes suspended particles and heavy metals in order to achieve optimum efficiency of the electrochemical oxidation.

Two container based demonstrator plants in Waterval, South Africa and Ressano Garcia, Mozambique, are in operation since months, the water sources being Klip river and Inkomati river, respectively. The demonstrators are capable of purifying water in accordance with World Health Organization (WHO) and South African SANS 241 standards. Autonomous operation by local staff has been successfully demonstrated so far with the South African unit. It is equipped with solar panels

and batteries for off-grid operation and has already been tested in the 24-hour operation mode. 7 – 8 hours of solar radiation are sufficient to produce at least 10 000 liters per day of safe water, which is sufficient for supplying 300 people.

Socio-economic and economic impact

The SafeWaterAfrica technology will contribute to the improvement of the potable water supply situation, thus addressing United Nations Sustainable Development Goals (SDG) 6 and 3. In the rural communities, this will mean - particularly for women and children – a relief in time-consuming water collection and, as a result, more opportunities for education and productive pursuits (SDG 5). Good health will also affect school absence times for pupils with the corresponding positive effects on education. On the economic side, new qualified job opportunities in rural areas will be created by local system fabrication, installation, operation and maintenance (SDG 8).

Outlook

Work will continue to create and increase awareness for the SafeWaterAfrica system among all relevant public and private stakeholders. In addition, business models were developed to roll-out the technology in the Southern Africa Development Community.

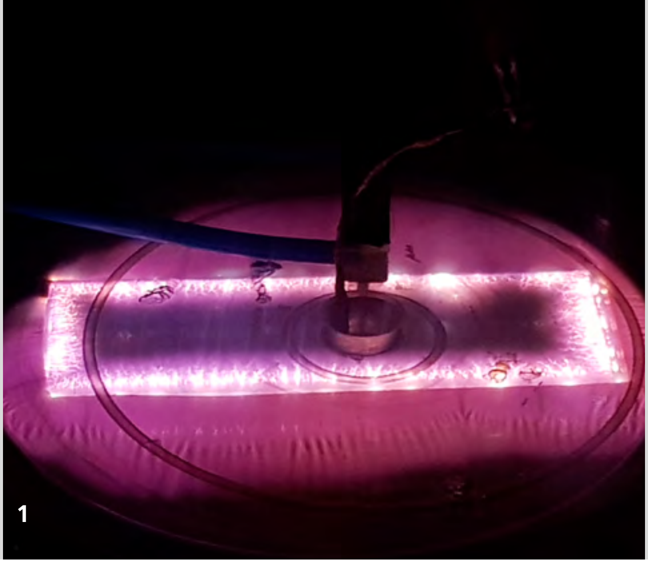
1 *Demonstrator in South Africa: overall view including the solar panels supplying the electrical power needed.*

2 *Water purification unit in Ressano Garcia, Mozambique.*

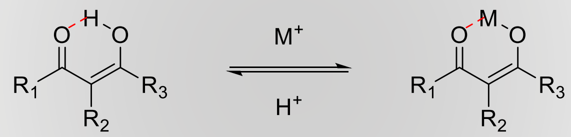
3 *Controlling the operation of the electrochemical oxidation unit by a local operator.*

CONTACT

Dr. Lothar Schäfer
Phone +49 531 2155-520
lothar.schaefer@ist.fraunhofer.de



1



2

6 CLEAN WATER AND SANITATION

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

MODIFICATIONS OF MEMBRANES FOR WASTE-WATER TREATMENT OF HEAVY METALS

The Fraunhofer IST has developed an atmospheric pressure plasma process to specifically functionalize filter membranes in order to improve the purification of wastewater from heavy metals.

The challenge

According to the Food and Agriculture Organization (FAO), 1.8 million people in the United States alone will suffer from absolute water shortages in 2025. The treatment of water of suitable quality is therefore of enormous importance. The aim of the "M²ARS" project was to develop a surface-functionalised filter membrane made of low-cost polypropylene (PP) which binds harmful metal ions contained in water to the surface of its pores in a highly selective manner. A further advantage in addition to this selectivity is that the filtering is based on the principle of adsorption, so that the membrane does not have to be nanoporous. This eliminates the need for high pressures. At the same time, the risk of blockage of the membrane is significantly reduced. The atmospheric pressure plasma process for functionalizing the membrane allows plasmas to be ignited even in the smallest cavities down to 10 µm.

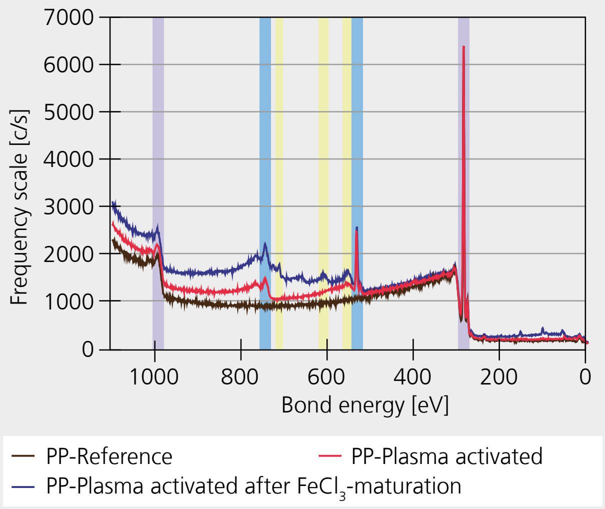
The surface treatment

Metal ions can be bound in the form of so-called chelate complexes. The metal ions form the central atom, which is bound by a multidentate ligand, i. e. a molecule which has at least two free electron pairs. In this coordinative bond, the binding electrons are provided solely by the ligand. Using atmospheric pressure plasma functionalization, the Fraunhofer IST was able to generate so-called β-diketones on the PP surface, which bind the metal ions as ligands in the form of chelate complexes (see Fig. 2). To this end, a suitable test rig for the generation of β-diketones was first set up and tested using a plasma process based on the principle of dielectric barrier discharge (DBD) at atmospheric pressure. By using porous electrode materials, the gas flow could be directed through the membrane (see Fig. 1).

The results

Within the project period, a basic functional proof on flat substrates could be provided: the β-diketones on the PP surface as well as the binding of metal ions could be successfully proven by FTIR-ATR and XPS spectroscopy. On the β-diketone-functionalized PP surface, for example, corresponding chelate complexes with iron(III) ions were formed after maturation in an aqueous iron(III) solution.

The opposite figure shows the overview XPS spectra of an untreated PP layer, a plasma-activated PP layer and a plasma-activated PP layer after maturation in an aqueous iron(III) solution. The desired oxygen-containing functionalization was achieved by plasma activation. Iron was clearly detected on the removed sample, whereas hardly any chlorine was detected. Thus, it could be shown that only iron ions were bound on the surface. In another test series, the plasma-functionalized PP layer was matured in a copper(II) solution. Here, too, the adsorption of copper was successfully demonstrated. The process was also transferred to the 5 mm thick filter material. The penetration depth of the treatment was examined by staining with methylene blue. So far, no complete penetration of the material has been achieved.



XPS overview spectra of an untreated polypropylene layer (black), a plasma-activated polypropylene layer (red) and a plasma-activated polypropylene layer after maturation in an aqueous iron(III) solution (blue). Detected carbon peaks are highlighted in grey, oxygen peaks in blue and iron peaks in yellow.

1 *Atmospheric pressure plasma treatment of a polypropylene membrane with an average pore size of 40 µm by dielectric barrier discharge (DBD).*

2 *Mechanism of chelate complex formation with ß-diketones as ligands.*

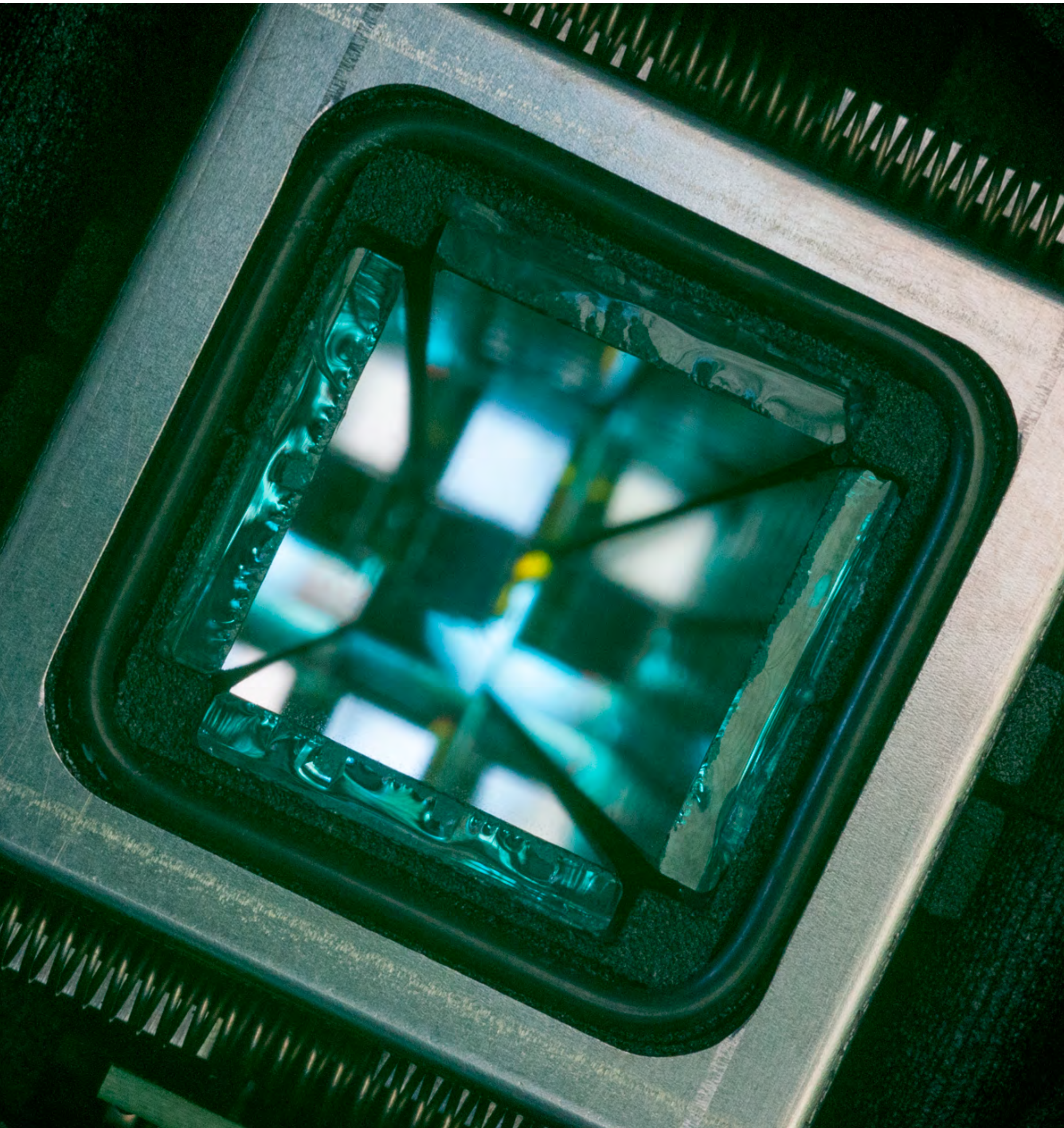
Outlook

In the future, optimizing plasma-activation and adapting membrane material (e. g. thickness, membrane material) should result in full material activation. Additional plans include testing membrane material with regard to filtration performance of metals. One important focus will thereby be the membrane regeneration and the relating recovery of filtered metals. On the basis of the evaluated plasma process, which can be easily transferred into an industrial roll-to-roll process, further interesting research fields can be opened up, such as the isolation of fine chemicals from industrial waste materials. In paper production, for example, more than 500 million tons of black liquor are produced annually worldwide, which, in addition to lignin as the main product, contains other valuable chemicals such as vanillin, pesticides and pigment carbon black.

CONTACT

Rowena Duckstein, M. Sc.
Phone +49 531 2155-619
rowena.duckstein@ist.fraunhofer.de

SERVICES AND COMPETENCIES

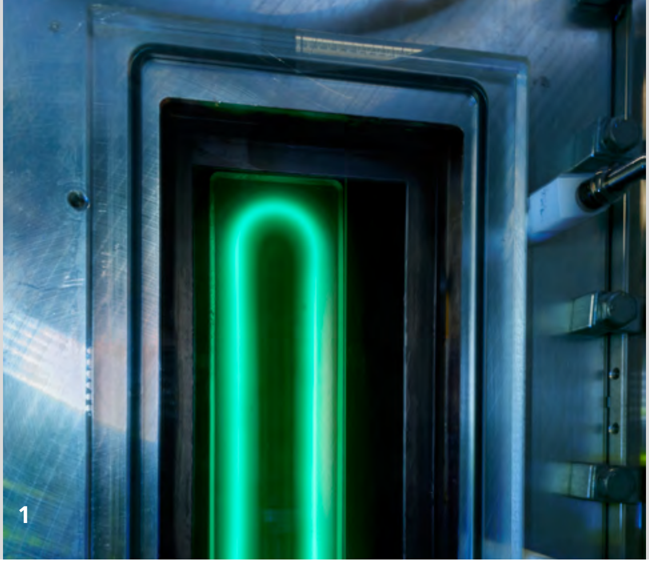


In pursuing the business units that were showcased in the previous chapters the Fraunhofer IST utilizes a wide spectrum of competencies. The focus is on the following technologies:

- Physical vapor deposition
- Chemical vapor deposition
- Plasma diffusion
- Atmospheric pressure plasma processes
- Electrochemical processes
- Laser technology

In addition, the Fraunhofer IST provides recognized competencies for a variety of coating systems. The institute offers a broad spectrum of cross-sectional services: Surface pretreatment, thin film development, surface modification, process technology (including process diagnostics, modeling and control), digital process automation, cyber-physical product and production systems, sustainable factory systems and life cycle management, energy storage systems, surface analysis and thin film characterization, training, application-oriented film design and modeling, simulation, system design, device and equipment manufacturing and technology transfer.

Demonstrator of a mobile measuring gun with luminescent polymeric carrier.


1


2

LOW PRESSURE PROCESSES AND ATMOSPHERIC PRESSURE PROCESSES

Physical Vapor Deposition (PVD)
- Magnetron sputtering
- Highly ionized pulsed plasma processes like HIPIMS, MPP
- Hollow cathode processes

Chemical Vapor Deposition (CVD)
- Hot-wire CVD
- Atomic layer deposition (ALD)
- Plasma-enhanced CVD (PECVD)

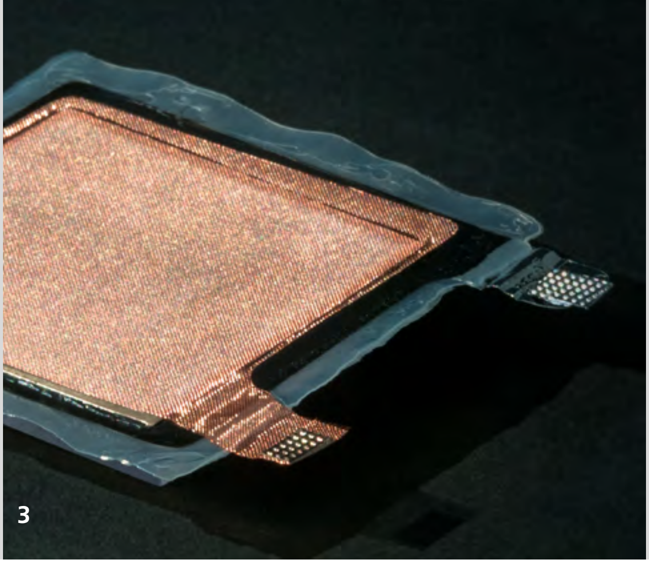
Plasma diffusion
- Nitriding / Carbonitriding
- Oxidizing
- Boriding

Atmospheric pressure plasma
- Plasma polymerization
- Dielectric barrier discharge
- Microplasma and plasma printing
- Integration of plasma in additive production processes
- Plasma particle coating
- Cold plasma spraying

Electrochemistry
- Galvanical metallization
- Chemical metallization
- Metal deposition from ionic liquids
- Dispersion deposition

Laser technology
- Laser-plasma hybrid processes
- Laser-induced fluorescence
- Laser structuring

Surface chemistry
- Dip coating
- Spin coating
- Photopolymerization
- Chemical derivatization


3

ENERGY STORAGE AND SYSTEMS

Energy storage development and production engineering

- Development of mobile and stationary energy storage devices and systems through to industrial maturity
- Formulation and production strategies for solid-state batteries*
- Scalable manufacture and fabrication of materials for energy storage systems*
- Particle and surface coating
- Surface functionalization
- Characterization of particles, powders and suspensions*
- Electrode manufacture*
- Cell characterization and safety*

Sustainable factory systems and life cycle management

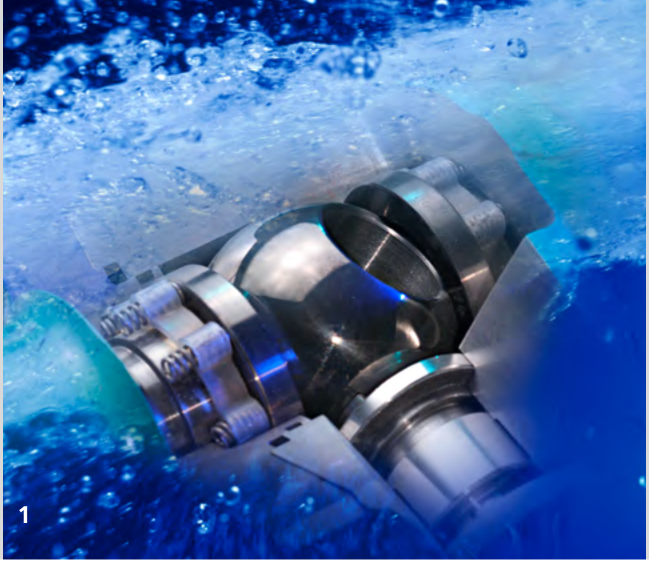
- Battery cell production*
- Model-based planning and operation of battery production systems
- Simulation from product to factory scale
- Networking of virtual models with real battery production in cyber-physical production systems (CPPS)
- Data mining and data analytics along the battery process chain
- Ecological-economic life cycle analyses

*in cooperation with the Battery LabFactory Braunschweig (BLB).

1 *HIPIMS-Plasma.*

2 *Plasma discharge in synthetic air.*

3 *Structure of a battery cell.*



1

2

COMPETENCE COATING SYSTEMS

Friction reduction and wear protection

- Amorphous carbon coatings (DLC)
- Diamond coatings
- Hard coatings
- Nitride/Cubic boron nitride (cBN)
- Metal coatings
- Plasma diffusion/DUPLEX processes
- Dry lubricants
- Erosion protection
- Corrosion protection
- Anti-adhesion and antifouling coatings
- Diffusion barriers

Electrical and optical coatings

- Precision optics
- Transparent conductive coatings
- Electrochromic coatings
- Low-E and sun control coatings
- Diamond electrodes
- Silicon-based coatings for photovoltaics and microelectronics
- Semiconductors (oxide, silicon-based, diamond)
- Insulation coatings
- Piezoelectric coatings
- Magnetic coatings
- Plastics metallization

Micro- and nanotechnology

- Thin-film sensor technology
- Microtechnology
- Nanocomposites
- Control of coating adhesion
- Structured surface coating and activation

Biofunctionalization

- Antibacterial coatings
- Adhesion and anti-adhesion coatings
- Chemical reactive surfaces

Photocatalysis

- Air and water purification systems
- Photocatalytically active coatings with antimicrobial effectiveness

FURTHER COMPETENCIES

Pretreatment and functionalization

- Wetchemical cleaning
- Functionalization and coating of interfacial layers
- Surface structuring
- Plasma activation and cleaning
- Oxidation and reduction of metals
- Plasma surface modification
- Optimization of adhesive bonds

Product and production systems

- Life cycle management
- Sustainable factory planning
- Design of process chains and production systems

Simulation

- Simulation of plants, processes and coating layer properties
- Model-based interpretation of coating processes

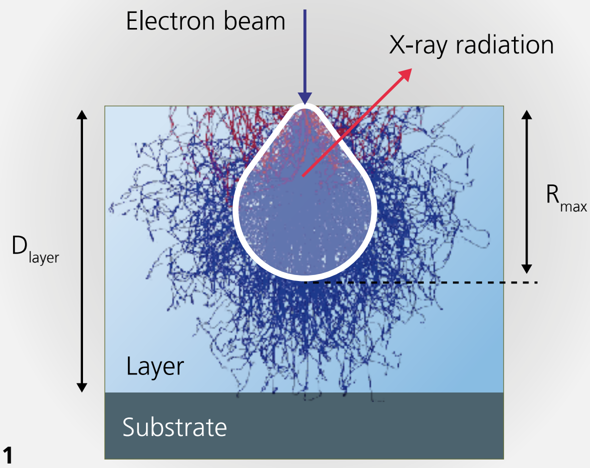
Analytics and quality assurance

- Chemical analysis
- Crystal structure analysis
- Microscopy
- Analysis of chemical reactive surfaces
- Optical and electrical characterization
- Plasma diagnostics
- Tribological tests
- Mechanical tests
- Standardized photocatalytic measurement technology including test systems and devices

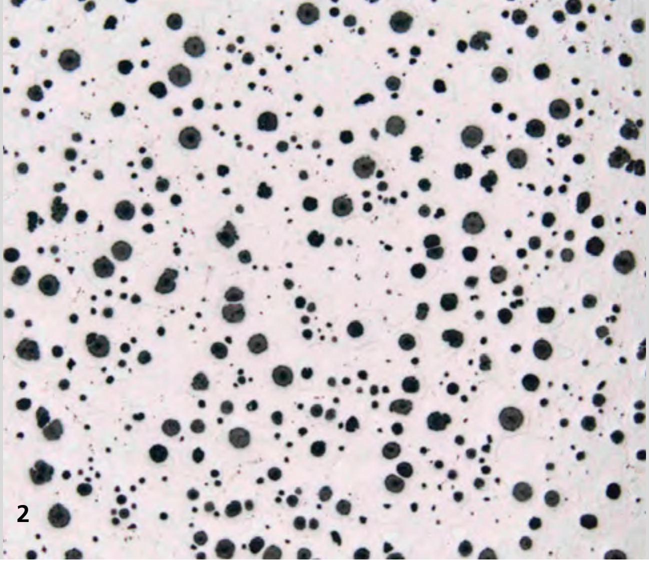
1 *Coated ball valve: reduction in input power.*

2 *Demonstrator of a mobile measuring gun with luminescent polymeric carrier.*

3 *Rockwell test for reviewing the coating adhesion.*



1



2

EPMA-ANALYSIS OF THIN FILMS: FILM THICKNESS AND COMPOSITION

The chemical composition and thickness of thin coatings are often the most important parameters determining the function of a film. Quality assurance of these parameters is therefore essential, during both development and production. Electron Probe Micro Analysis (EPMA) is a versatile method for the characterization of thin films with thicknesses ranging from nanometers to millimeters. It allows the non-destructive determination of the chemical composition and, in the case of films in the sub-micrometer range, also of the film thicknesses – with high accuracy and detection sensitivity.

The measuring principle

In EPMA analysis, a finely focused electron beam is directed to the sample surface in order to excite X-rays, which are then analyzed with the aid of several wavelength-dispersive crystal spectrometers. From the intensity of the characteristic X-ray radiation, the chemical composition can be determined with an absolute accuracy of 1–3 wt%. In the case of films thinner than 500–1000 nm, the thickness of single and multi-layer coatings can also be determined non-destructively under certain boundary conditions.

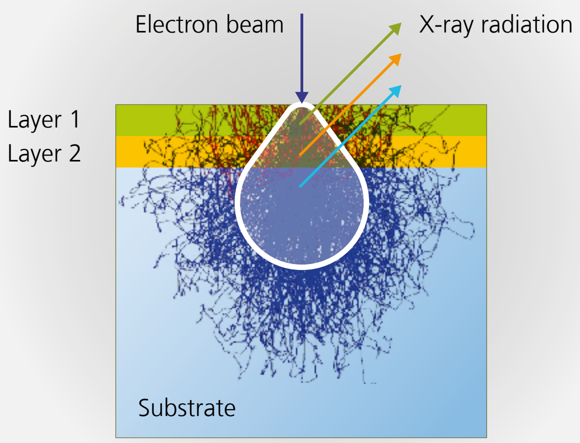
Bulk analysis of the chemical composition

If the layers are relatively thick, i.e. > 1 µm, the chemical elemental composition can be measured independently of the substrate (see Fig. 1). The detection limit is thereby approx. 0.01 wt% and the relative accuracy 0.1 wt%. The spatial resolution lies at around 1µm due to the finely focused electron beam. Consequently, one- and two-dimensional distribution of the chemical composition can be measured very well. For films of > 10 µm, this is also possible at the cross-section to measure depth profiles of chemical composition. Figure 2 shows a cross-section through a piece of cast iron with graphitic precipitations. A linescan across one of the particles shows, in addition to the carbon in the particle, 0.03 wt% phosphorus and up to 0.13 wt% boron in a shell of the particle close to the surface (see adjacent upper Figure). This demonstrates the high detection sensitivity and the very good spatial resolution of the method.

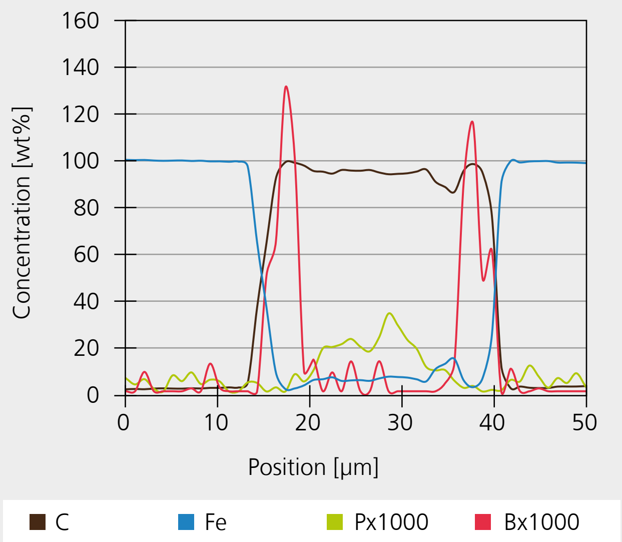
Thin-film analysis

For films which are thinner than 500–1000 nm, the film thickness can be measured simultaneously with the chemical composition. In this case, the electron beam will penetrate through the film into the substrate. The method is even possible with twofold or threefold film systems (see Fig. 3). The prerequisite is that each chemical element only occurs in one of the layers or in the substrate, in order for the element radiation to be unambiguously assigned to one of the layers or the substrate.

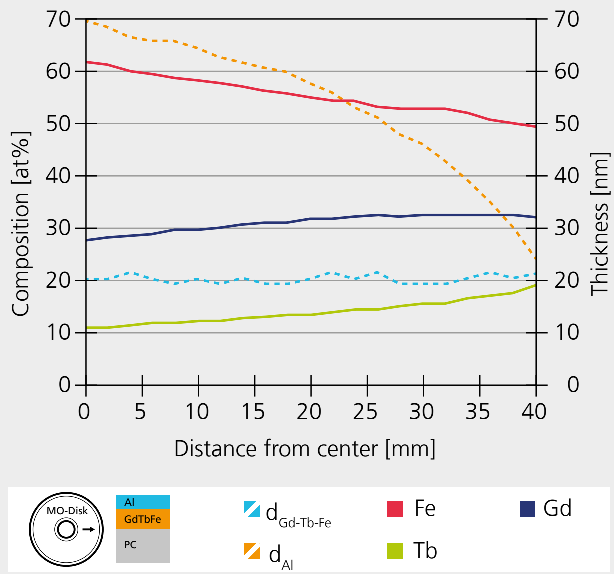
The adjacent graphic below shows an example of a magneto-optical storage disk made from polycarbonate with a Gd-Tb-Fe functional layer at the base which is furnished with an Al protective layer. With the aid of EPMA thin-film analysis, the thickness of both films and the stoichiometry of the concealed magneto-optical layer can be simultaneously determined position-dependent point-by-point over the radius of the disk. A strong gradient in the film thickness of the GdTbFe film from 70 to 20 nm can be observed.



3



EPMA linescan over graphitic precipitation in cast iron.



Linescan over a magneto-optical storage disk, with an Al top layer and GdTbFe functional layer on a polycarbonate substrate.

1 *EPMA analysis of thick films independent of the substrate: penetration depth of the electrons < than the film thickness.*

2 *Cross-section of cast iron with graphitic precipitations.*

3 *EPMA analysis of thin films. Electron penetration depth is > than the film thickness. Simultaneous determination of film thickness and composition is possible.*

At the same time, the (Gd+Tb)/Fe ratio varies significantly over the radius of the disk. The measurement duration for this analysis was approx. 45 min.

The thin-film analysis is so sensitive that, under favorable conditions, even monolayers of a material lying below some 10–100 nm of another material can be detected and measured. In a low-e glass coating, for example, it was possible to determine the thickness of a 0.3 nm-thick NiCr film below 30 nm of several metal oxide layers and to measure the stoichiometry from Ni to Cr.

More detailed explanations and further examples can be found in Vakuum in Forschung und Praxis, Vol. 31, No. 3 (June 2019), pp. 26–36.

CONTACT

Dr. Kirsten Schiffmann
Phone +49 531 2155-577
kirsten.schiffmann@ist.fraunhofer.de

NAMES, DATES, EVENTS

TRADE FAIRS, EXHIBITIONS, CONFERENCES

Hannover Messe 2019

Hannover, April 1 – 5, 2019. At Hannover Messe this year, the Fraunhofer IST focused on important topics such as Industry 4.0, digitalization, simulation, and the modeling of materials, processes, product and production systems as well as whole factories. At the joint Fraunhofer booth "Digital Solutions & New Materials", the institute demonstrated to what extent digital solutions can facilitate and accelerate the development of innovative products using their work on the simulation of coating processes. In addition to that, the latest findings in the fields of tribological systems and integrated sensor systems were presented.

SVC TechCon 2019

Long Beach, California, USA, April 27 – May 2, 2019. The SVC TechCon took place for the 62nd time this year. The conference is an important meeting place for experts from the field of vacuum coating technologies and materials. As part of the two-day technical exhibition and in addition to more than 150 other exhibitors, the Fraunhofer IST presented the latest findings in the area of HIPIMS technology and optical coatings. The institute also shared results in the area of simulation regarding dust particle simulation, 3D medium frequency simulation, and the MOCCA+® monitoring system (Modular Coating Control Application).

Paris Air Show 2019

Le Bourget, France, June 17 – 23, 2019. At the leading trade fair of the aerospace industry, the Fraunhofer IST presented the latest coating developments for space applications at the joint booth of the German Aerospace Industries Association (BDLI), including metallized CFRP waveguide antennas for the "Sentinel mission", coated optical filters, and lenses for space applications.

10th International Conference on High Power Impulse Magnetron Sputtering (HIPIMS)

Braunschweig, June 19 – 20, 2019. The Fraunhofer IST took part in the 10th International Conference on High Power Impulse Magnetron Sputtering (HIPIMS) and the associated industrial exhibition as a scientific partner. For scientists from all over the world, the conference serves as a platform to exchange information about the latest results and trends in the field of plasma surface engineering. One segment of this year's conference was dedicated to sputtering technologies for the first time, with employees of the "Highly Ionized Plasmas and PECVD" group contributing scientific posters.

2

1 View of the Fraunhofer joint booth at Hannover Messe 2019.

2 Fraunhofer IST booth at SVC TechCon 2019.

LASER World of Photonics 2019

München, June 24–27, 2019. LASER World of Photonics is the world's leading trade fair for components, systems, and applications in the field of optical technologies. The integrated congress at the Laser trade fair also highlights the whole spectrum of photonics from a variety of perspectives. The Fraunhofer IST took the opportunity to present ultra-precise optical interference and bandpass filters, which were produced with EOSS® (Enhanced Optical Sputtering System).

The system allows batch processing of up to ten substrates simultaneously with extreme precision and uniformity of coatings with highly complicated layer designs and high process reliability. In addition, the institute presented a demo version of the monitoring system MOCCA+® (Modular Coating Control Application), which is used for coating thickness control and automation of the entire coating process in the field of precision optics.

Rapid.Tech 2019

Erfurt, June 25–27, 2019. For the very first time, the Fraunhofer IST took part in the international trade fair for additive manufacturing as part of a joint booth of the Fraunhofer Additive Manufacturing Alliance. Additive manufacturing offers some important overlap with surface technology. The Fraunhofer IST works on various topics in the field, including the coating of powders and the in-situ plasma treatment of 3D-printed polymeric frameworks, so-called scaffolds.

1


2

TRADE FAIRS, EXHIBITIONS, CONFERENCES

V2019 – Vakuum & Plasma

Dresden, October 8 – 10, 2019. The Fraunhofer IST participated in this year's symposium on thin-film surface technology as a part of the accompanying industrial exhibition. The thematic focus of the V2019 was the plasma and vacuum technology for surface finishing in the fields of energy, medicine, optics, tools and components as well as atomic layer deposition (ALD). Furthermore, the institute contributed to the scientific program of the conference.

Apprenticeship fair "Market of Possibilities"

Wolfenbüttel, October 23, 2019. This year the Fraunhofer IST presented itself for the the first time at the "Market of Possibilities" fair held at the Henriette Breymann Comprehensive School in Wolfenbüttel. Interested students were able to obtain information on the Office Management Assistant and Physics Laboratory Assistant apprenticeships.

International Battery Production Conference IBPC 2019

Braunschweig, November 4 – 6, 2019. With regard to sustainable developments and processes, the global demand for sustainably manufactured electrochemical energy storages is constantly increasing. In spite of this high demand, the production process of batteries is frequently neglected. The International Battery Production Conference IBPC, which took place for the second time in 2019, bridges this gap and therefore provides an international exchange and networking platform. For the first time, the Fraunhofer IST participated as a scientific partner of the conference and assumed the conference chair together with representatives of the Institute of Machine Tools and Production Technology (IWF) and the Institute for Particle Technology, both part of the TU Braunschweig.

Space Tech Expo Europe

Bremen, November 19 – 21, 2019. As part of the joint booth of the Fraunhofer Space Alliance, the Fraunhofer IST participated in next to other institutes and exhibited various coated components suitable for aerospace. The three-day trade fair displays the latest innovations and components from technical designers, subsystem suppliers and system integrators for civil, military and commercial space flight.

Formnext 2019

Frankfurt am Main, November 19 – 22, 2019. In terms of additive manufacturing and the next generation of industrial production, the exhibition Formnext is the right place for innovative companies from various sectors. For the first time, the Fraunhofer IST took the opportunity to participate in the motto "the future of 3D manufacturing" and presented selected topics of the institute in the field of additive manufacturing.


3

International Conference on Reactive Sputter Deposition RSD

Braunschweig, December 5 – 6, 2019. This year, the 18th International Conference on Reactive Sputter Deposition RSD took place in Braunschweig for the very first time. The conference including an accompanying exhibition organized by the Fraunhofer IST offered an excellent platform for the 100 participants from 22 countries to discuss latest trends and their implementations into new technologies and innovative products. The RSD is not only a scientific conference, which discusses reactive sputtering from physical principles to model-based simulation, but it also addresses industrial implementation represented impressively by the invited speakers.

The day before the conference, short courses were offered to interested visitors which provided participants with background information regarding sputtering technology. The accompanying exhibition of the conference offered another opportunity for exchange holding ten booths from international companies, which presented their newest developments and products.

1 *View of the Fraunhofer IST booth at V2019.*

2 *Trainees and trainers of the Fraunhofer IST at "Market of Possibilities".*

3 *Visitors of the technical exhibition during the RSD 2019.*

1

2

EVENTS, COLLOQUIA, WORKSHOPS

Science Day at Fraunhofer IST

Braunschweig, January 29, 2019. Third time in a row, the "Science Day" took place at the Fraunhofer IST. PhD students of the Fraunhofer IST and the Institute of Surface Technology IOT as well as the Institute of Machine Tools and Production Technology IWF of the TU Braunschweig had the opportunity to present their doctorate's current status to employees of the involved institutes. In an informal setting, information about the research topics were exchanged and discussed.

70 Years of Fraunhofer – #WHATSNEXT

On March 26, 1949, the Fraunhofer-Gesellschaft was founded and celebrates its 70th birthday this year. The motto of the anniversary year: "70 years of Fraunhofer. 70 years of future. #WHATSNEXT".

For the Fraunhofer IST, the anniversary of the founding was a cause for celebration as well. On that note, director Prof. Dr. Günter Bräuer gave a talk about "Quantum jumps and the missing colors of the sun" in front of his staff. Following that, the institute's directors, Professor Bräuer and Professor Herrmann, both cut the birthday cake, which was decorated with the spectrum of sunlight including the differently labeled absorption lines found by the society's eponym Joseph von Fraunhofer 200 years ago.

Winning team of "Hacking Engineering" chooses Fraunhofer IST technology

Berlin, May 17 – 19, 2019. The "Hacking Engineering Hackathon" is a new format initiated by the Fraunhofer-Gesellschaft and the VDMA, Europe's largest industry association for mechanical engineering. The idea is to bring together companies from fields of mechanical engineering and equipment technology, startups from research fields as well as interested students enabling them to develop innovative future technology. Within 48 hours, teams of participants were supposed to solve one out of four challenges. One of the winning teams picked the multifunctional thin-film sensor system developed by the Fraunhofer Institute for Surface Engineering and Thin Films for their solution and won "Kill the Valve".

TU Night 2019

Braunschweig, June 29, 2019. For the very first time, the Fraunhofer IST participated in the TU Night, a mixture of science festival and Campus Open Air. As part of the technical exhibition, which took place from 6 to 11 pm, the institute presented a variety of topics at a joint booth with the Battery LabFactory Braunschweig BLB, the Automotive Research Centre Niedersachsen NFF and the Open Hybrid LabFactory e. V. OHLF. According to the motto "knowledge moves future", scientists of the Fraunhofer IST provided insights into current research work for visitors of the science night. Among other things, waveguides made of metallized CFK for the


3

antennas of the "Sentinel mission" and optical filters for space applications, electrochemical systems with diamond electrodes for water purification as well as an exhibit from the field of battery research were presented.

European-Japanese Joint Workshop on Photocatalysis Standardization

Berlin, October 24, 2019. This year, a staff member of the Fraunhofer IST participated in the "European-Japanese Joint Workshop on Photocatalysis Standardization". During this workshop, which takes place on a regular basis, representatives of industry and various professional associations draft, discuss and pass new propositions on standardization for the field of photocatalysis.

Vintage Class Alumni

The Fraunhofer Vintage Class is a program directed at internal scientific managers to promote acquisition of key positions in upper institute management. Annual network meetings as well as meetings with alumni are part of the program. This year, the Vintage Class Alumni meeting, which was also visited by Fraunhofer IST employees, took place in Braunschweig. Next to visiting the Open Hybrid LabFactory (OHLF) and the Battery LabFactory (BLB), guided tours through the Fraunhofer-Institutes IST and WKI were part of the program, too.

1 *Fraunhofer IST directors Prof. Dr. Günter Bräuer (left) and Prof. Dr. Christoph Herrmann (right) cut the birthday cake for the 70th anniversary of the Fraunhofer-Gesellschaft.*

2 *TU Night visitors at the Fraunhofer IST booth.*

3 *Participants of the workshop "European-Japanese Joint Workshop on Photocatalysis Standardization".*

1

2

PRIZES AND AWARDS

Rudolf Seeliger Prize 2019

Cottbus, June 17 – 19, 2019. During this year's 19th symposium for plasma technology, Prof. Dr. Claus-Peter Klages was honored with the Rudolf Seeliger Prize for his contributions in the field of plasma research. The prize honors Prof. Dr. Klages' long-standing work in the field of plasma technology development. Klages, who laid the foundation for his work in the field of plasma technology during his time at the Philips Research Laboratory in Hamburg – the nucleus of the Fraunhofer IST – has shaped the institute significantly since its founding in 1990. Initially, he concentrated on the deposition of coatings through activated CVD processes and here on diamond technology in particular. In the mid-nineties, he transferred his scientific focus to the field of plasma technology, where he distinguished himself as an internationally recognized expert in the field of atmospheric pressure plasma processes.

Claus-Peter Klages represents not only plasma technology but also quality in research. "This can be confirmed not only by colleagues but also particularly by doctoral students, whose work he has corrected and annotated – in red, of course," recalls Dr. Andreas Pflug, with a wink. The group leader for simulation at the Fraunhofer IST gave the laudation at the award ceremony: "Professor Klages was an important role model for all of us. He was extremely productive, acquired, travelled, researched and published a great deal. During his time at the Fraunhofer-Gesellschaft alone, he composed 116 articles for professional journals, 159 conference papers, 55 patent specifications and 9 book chapters." Nevertheless, he was always ready to listen to other people. In the case of tricky questions or technical problems, he always had a good idea or a suitable publication at hand. "His wealth of knowledge continues to impress – and not only us," reveals Dr. Pflug.

The Rudolf Seeliger Prize has been awarded by the Deutsche Gesellschaft für Plasmatechnologie e. V. (German society for plasma technology, DGPT) since 2001. Within the framework of the biennial plasma technology conference, the society honors therewith the excellent work of deserving scientists in the field of plasma technology.

Fraunhofer IST trainees deliver top performance

Both Fraunhofer IST trainees Conrad von Bülow and Jonas Boomers passed their final physics laboratory technician examinations. Von Bülow achieved a total score of 1.4 and therefore ranks as one of the chamber's best. As one of the best trainees of the Fraunhofer-Gesellschaft, von Bülow was honored in München. Moreover, von Bülow and Tobias Alexander Wehke, who trained as an IT specialist, were awarded for their outstanding performance in their final examination with an honorary certificate by the Industrie- und Handelskammer Braunschweig. Congratulations!

INPLAS Honorary Award

Prof. Dr. Günter Bräuer, founder and chairman of the board of INPLAS e. V. and director of the Fraunhofer IST, received the INPLAS honorary award during the 14th INPLAS general meeting at the company IHI Hauzer Techno Coating B.V. Prof. Dr. Bräuer was honored for his decades of contribution to the plasma community and his commitment to further develop plasma technology in Germany and Europe. On his initiative, the competence network INPLAS was established in 2005 and was accredited by "Kompetenznetze Deutschland" in 2006. The goal remains to integrate the enormous potential of plasma technology politically and application-oriented in current topics.

1 *Award winner Prof. Dr. Claus-Peter Klages.*

2 *Physics laboratory technicians Conrad von Bülow and Jonas Boomers together with their trainers Sven Pleger and Daniel Schulze as well as director Prof. Dr. Bräuer (f.l.t.r.).*

3 *INPLAS managing director Carola Brand, director of the Fraunhofer IST Prof. Dr. Günter Bräuer, INPLAS executive board member Dr. Michael Liehr, (f.l.t.r.).*

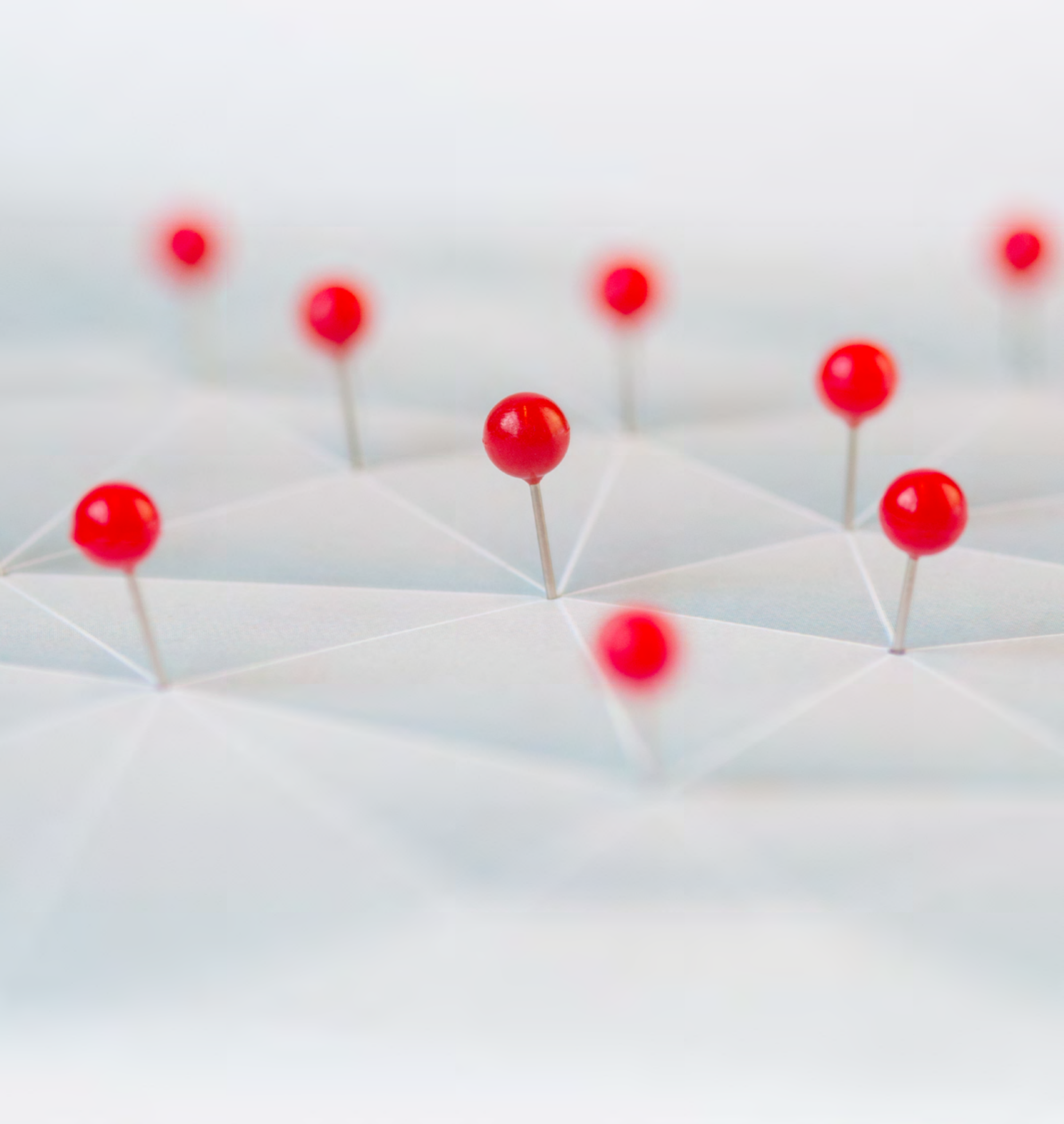
WE BID FAREWELL

We bid farewell to our employee, colleague, and friend Frank Schmidt, who passed away unexpectedly and too soon at the age of 52. For almost 21 years – already as a student – Frank Schmidt committed himself to our institute. In his field of expertise, gas flow sputtering, Frank, in his role as electrical engineer, made important contributions to developing new plasma sources. Furthermore, he, the competent skilled electrician that he was, always had a solution to offer. Not only his expertise but also his helpfulness and his humorous nature were known and liked by all of us.

We mourn a kind and greatly appreciated person whose memory we will honor. We express our condolences to his family.

1 *Dipl.-Ing. Frank Schmidt.*

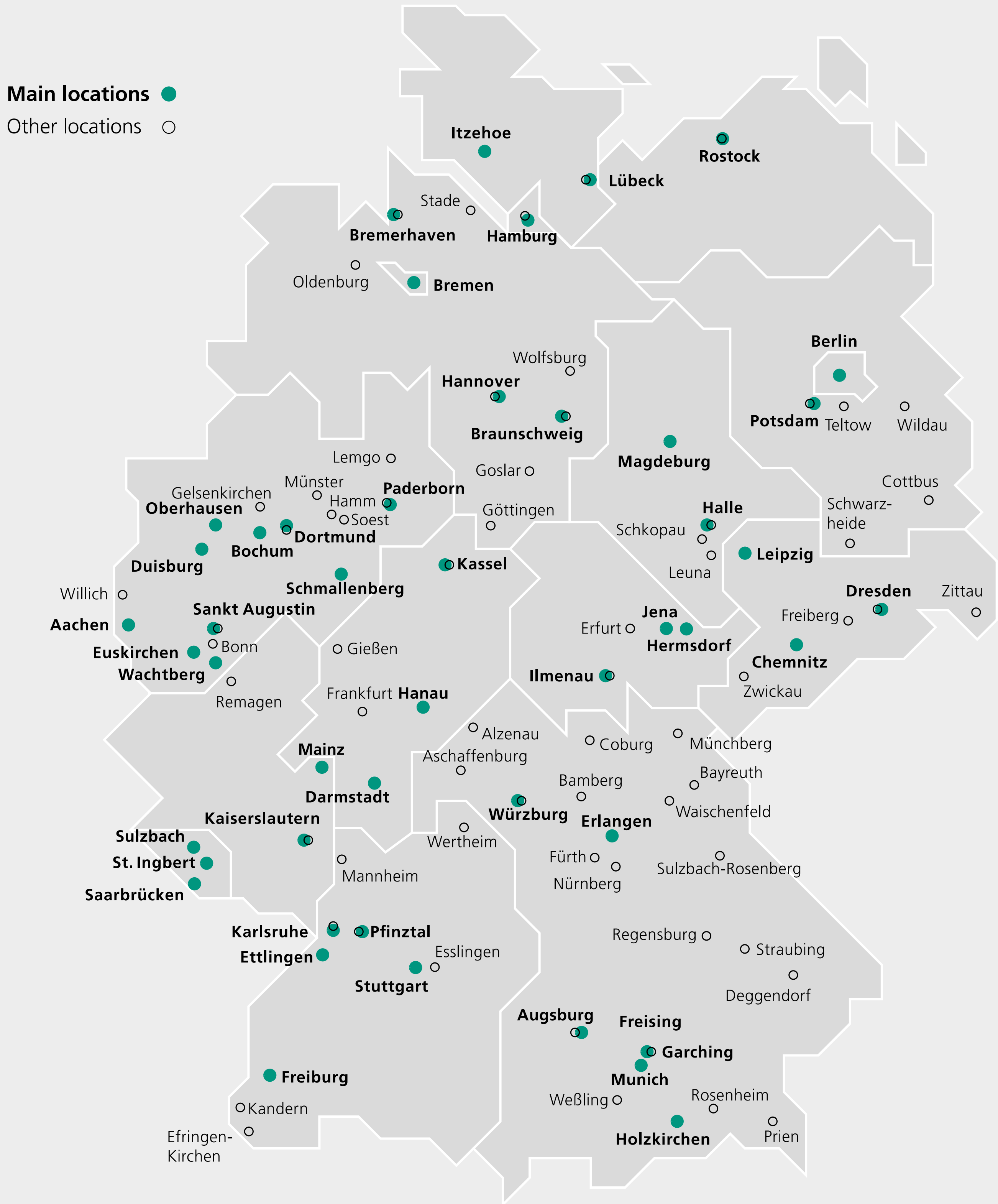
THE FRAUNHOFER IST IN NETWORKS



With its research and development activities, the Fraunhofer Institute for Surface Engineering and Thin Films IST is part of various internal and external networks which function with different points of emphasis in the field where business, science and politics interact and even clash. Within the Fraunhofer-Gesellschaft, the institute combines its competences with those of other Fraunhofer institutes in, amongst other things, the Fraunhofer Group for Light & Surfaces and in various Fraunhofer alliances in order to be able to offer customers and partners optimal – and even cross-technology – solutions for their specific tasks.

In addition, the Fraunhofer IST also looks out for future scientists and researchers. For this reason the institute networks intensively with educators, students and pupils in order to raise enthusiasm for the natural sciences and engineering at an early age and to encourage the upcoming generation of scientist.

THE FRAUNHOFER IST IN NETWORKS



THE FRAUNHOFER-GESELLSCHAFT AT A GLANCE

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

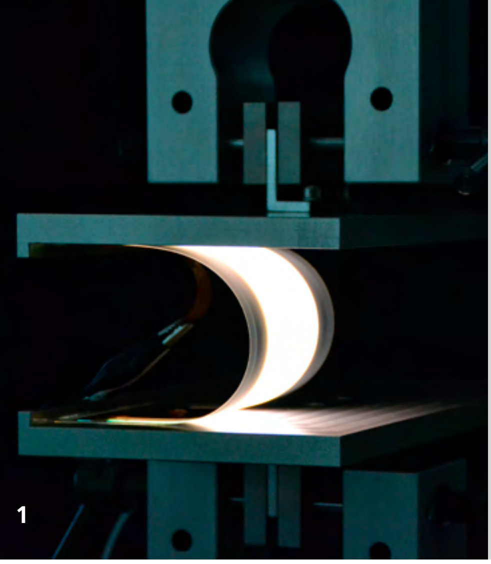
At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research institutions. The majority of our 28,000 staff are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.3 billion euros is generated through contract research. Around 70 percent of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining 30 percent comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society, and help train the future generation of scientists and engineers the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.



1

2

3

FRAUNHOFER GROUP LIGHT & SURFACES

Competency by networking

Six Fraunhofer institutes are cooperation in the Fraunhofer Group »Light & Surfaces« in the fields of laser, optics, metrology and coating technology. 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 these fields. 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 talents 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

Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP[1]

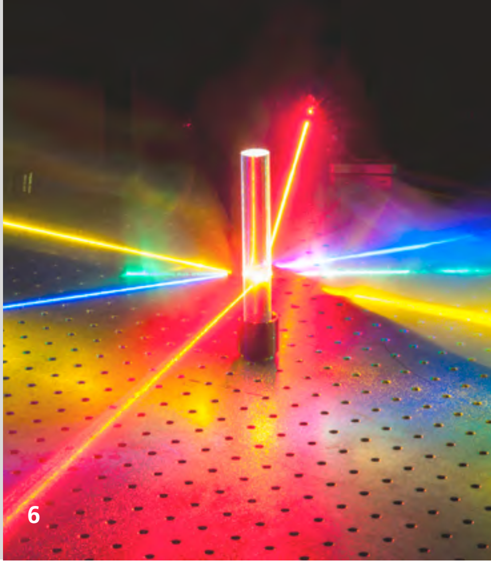
Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP works on innovative solutions in the fields of vacuum coating, surface treatment as well as organic semiconductors. The core competences electron beam technology, plasma-assisted large-area and precision coating, roll-to-roll technologies, development of technological key components as well as technologies for the organic electronics and IC/system design provide a basis for these activities. Thus, Fraunhofer FEP offers a wide range of possibilities for research, development and pilot production, especially for the processing, sterilization, structuring and refining of surfaces as well as OLED microdisplays, organic and inorganic sensors, optical filters and flexible OLED lighting. Our aim is to seize the innovation potential of the electron beam, plasma technology and organic electronics for new production processes and devices and to make it available for our customers.
www.fep.fraunhofer.de/en

Fraunhofer Institute for Laser Technology ILT[4]

With more than 540 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

4

5



6

Fraunhofer Institute for Applied Optics and Precision Engineering IOF[2]

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[6]

The Fraunhofer IPM develops tailor-made measuring techniques and systems for industry. In this way, the institute enables its customers to minimize their use of energy and resources, while at the same time maximizing quality and reliability. Fraunhofer IPM makes processes ecological and economical. Many years of experience with optical technologies form the basis for high-tech solutions in the fields of production control, object and shape detection, gas and process technology as well as thermal energy converters.
www.ipm.fraunhofer.de/en

Fraunhofer Institute for Surface Engineering and Thin Films IST[5]

The Fraunhofer Institute for Surface Engineering and Thin Films IST in Braunschweig is an innovative partner for research and development in surface technology, with expertise in the associated product and production systems. The aim ist to develop customized and sustainable solutions: from prototypes, through economic production scenarios, to upscaling to industrial magnitudes – and all this whilst maintaining closed material and substance cycles. | www.ist.fraunhofer.de/en

Fraunhofer Institute for Material and Beam Technology IWS[3]

Light and layer: Fraunhofer IWS works wherever lasers and surface technology meet. The Dresdner institute comes into play if the task is to deposit different materials layer by layer, to join, cut, functionalize or analyse. Services range from developing new techniques via integration into manufacturing, up to user-oriented support – in single-source responsibility. The Fraunhofer IWS is meeting the challenges of digitization with a focus on researching and developing solutions for »Industry 4.0« . | www.iws.fraunhofer.de/en

CONTACT

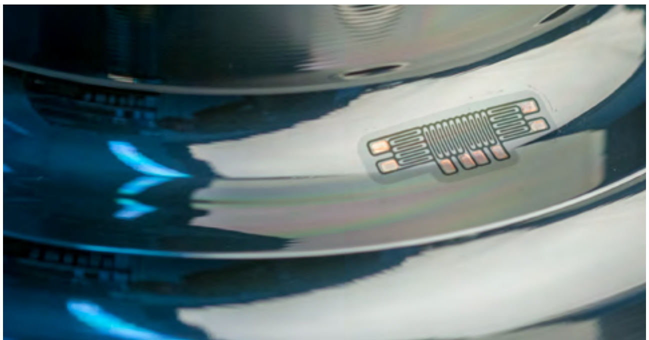
GROUP CHAIRMAN
Prof. Dr. Karsten Buse
karsten.buse@ipm.fraunhofer.de

GENERAL MANAGER
Dr. Heinrich Stülpnagel
Phone +49 241 8906-148
heinrich.stuelpnagel@ipm.fraunhofer.de

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

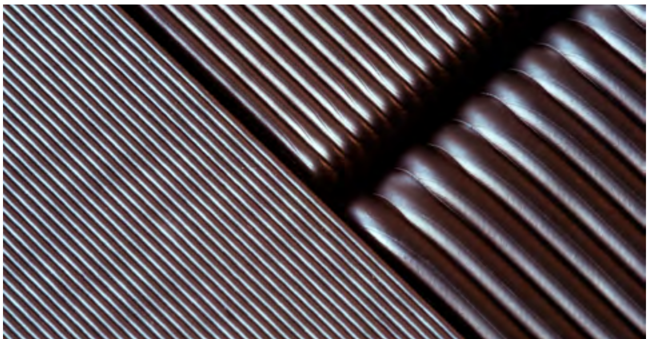
NETWORKING IN FRAUNHOFER ALLIANCES

The Fraunhofer IST is a member of the Fraunhofer-Gesellschaft alliances listed below. In 2019, the Fraunhofer IST also became a member oft he Fraunhofer Battery Alliance. The Fraunhofer Battery Alliance bundles the expertise of the Fraunhofer-Gesellschaft in the field of electrochemical energy storage devices. The more than 20 members of the Fraunhofer Battery Alliance direct their focus primarily on the development of suitable technical and conceptual solutions in the field of electrochemical energy storage devices, thereby taking particular account of the social, economic and ecological consequences, and transferring them into practical application. Both primary and secondary (rechargeable) systems thereby play a role: from the smallest applications, such as button cells, through to large stationary systems, such as redox flow batteries. Aim of the Alliance is to develop and further expand research in the field of electrochemical energy storage devices into a central business area. The competencies of the Fraunhofer Battery Alliance include the topics of materials, cell production, systems, simulation, and testing.



ADAPTRONICS

AUTOMOBILE PRODUCTION

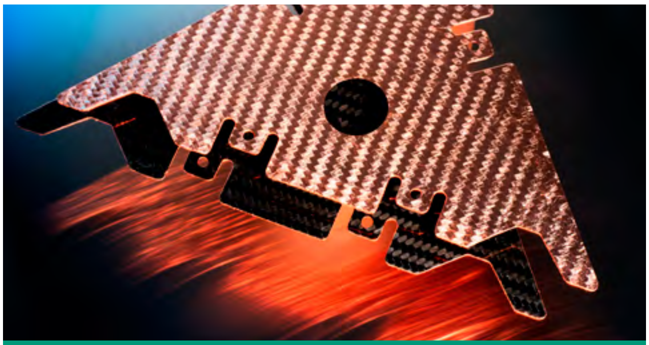


ADDITIVE MANUFACTURING

CLEANING TECHNOLOGY

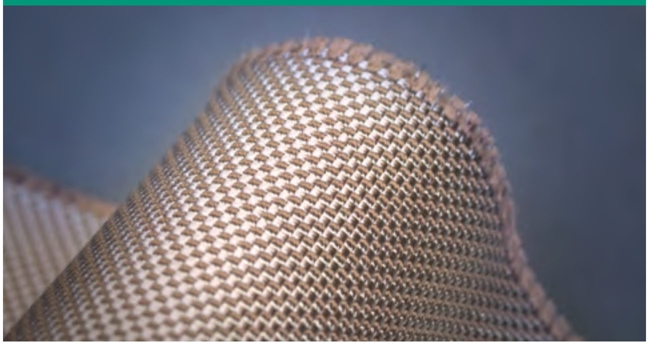
BATTERY

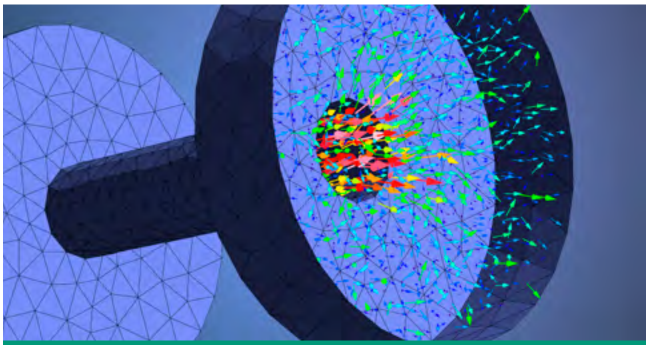
LIGHTWEIGHT DESIGN



SPACE

TECHNICAL TEXTILES





SIMULATION

WATER SYSTEMS (SYSWASSER)

REGIONAL AND NATIONWIDE NET-WORKING

A stronger networking and interlinking of both research topics and research protagonists is at the forefront of the activities of the Fraunhofer IST, not only in Braunschweig but also throughout Germany. As a result, research efficiency can be increased. The aim is to offer customers and partners optimal, trans-technological solutions for their assignments.

ForschungRegion Braunschweig

In order to network knowledge, to sustainably promote innovation and to strengthen the leadership position of the science region Braunschweig, in 2004, a total of 27 universities, colleges, federal research institutes, Helmholtz institutes, Fraunhofer institutes, research facilities of the Leibniz Association, museums, libraries, the Klinikum Braunschweig and further institutions with internationally highly regarded research joined forces to form the ForschungRegion Braunschweig e.V. – and the Fraunhofer IST is a participant.

Fraunhofer IST becomes a member of the Open Hybrid LabFactory e.V. (OHLF) and the Fraunhofer Project Center Wolfsburg

Lightweight construction and electromobility are two keywords which play a significant role in the future of the automotive sector, in particular as regards energy saving and resource conservation. The OHLF research campus has therefore set itself the goal of researching and developing new and innovative lightweight construction concepts for the automotive industry. The work at the OHLF thereby encompasses the entire value chain for hybrid components: from the concept, through textile production and the manufacturing process, and on to recycling. The Fraunhofer IST has recently also become a member of the lightweight-construction campus.

Through its admission to the Open Hybrid LabFactory, the Fraunhofer IST was this year also accepted as a new member of the Fraunhofer Project Center Wolfsburg, which is integrated into the research campus in terms of location and content. The Project Center is also focusing on the development of a comprehensive process chain for lightweight structures within the automotive sector.

Further cooperations with the TU Braunschweig

- Battery LabFactory Braunschweig BLB
- Laboratory for Emerging Nanometrology LENA
- Automotive Research Centre Niedersachsen NFF
- Aeronautics Research Centre Niedersachsen NFL
- Center of Pharmaceutical Engineering PVZ
- Open Hybrid LabFactory e.V.

Strategic partnership with the Kompetenzzentrum Tribologie in Mannheim

On 10th July, the Hochschule Mannheim - University of Applied Sciences and the Fraunhofer IST signed a cooperation agreement concerning the expansion of their joint research activities in the field of tribology and surfaces. Since 2018, the Kompetenzzentrum Tribologie has been working closely with the Braunschweig institute within the framework of the newly established DFG priority program SPP2074 "Fluidfreie Schmiersysteme" (fluid-free lubrication systems).

1 *Research partners of the Fraunhofer IST in the district of Braunschweig and the region.*

1

2

PROMOTION OF YOUNG TALENT AND TRAINING AT THE FRAUNHOFER IST

Promoting young talent – for the Fraunhofer Institute for Surface Engineering and Thin Films IST, this means not only being active as a trainer and in the university context but also introducing adolescents to scientific topics, helping them to overcome their fears and anxieties, and filling young people with enthusiasm for industry-related research. The encouragement and support of pupils and students who are interested in the research fields of the Fraunhofer IST once again formed an important part of the institute's work in 2019.

Future day for boys and girls at the Fraunhofer IST

Braunschweig, 29th March 2019: This year, pupils from grades 5-9 once again had the opportunity to spend a day obtaining an initial taste of the research work performed by the Fraunhofer institutes IST and WKI within the framework of the "Future Day for Girls and Boys". A total of 24 young researchers – 13 girls and 11 boys – spent a day immersed in the day-to-day research work of the Fraunhofer institutes.

Following a presentation of the two institutes, the participants at the Fraunhofer IST were able to produce films by means of cathode sputtering and to perform flame tests with various salts. At the WKI, the production and processing of particle boards as well as mechanical material testing were included in the program. At the end of the day, the girls and boys were able to take their coated works home as souvenirs.

Apprenticeship professions

In collaboration with the Fraunhofer WKI, the Fraunhofer IST provides the training for a total of seven different professions:

- Physics laboratory assistant
- Surface-coater (Electroplater)
- Business person for office management
- Specialist for media and information services, field: Library
- IT Specialist, field: System Integration
- Wood technician
- Industrial mechanic

This year, the institute received a certificate of honor from the Braunschweig Chamber of Industry and Commerce for its performance as a particularly successful training facility. Two of the graduates were honored for their particularly good performance in the final examinations.

1 *13 girls and 11 boys were allowed to produce films by means of cathode sputtering at the Fraunhofer IST.*

2 *A physics laboratory assistant at work.*

3 *The new physics laboratory assistants Conrad von Bülow and Jonas Boomers with their trainers Sven Pleger and Daniel Schulze and the Institute Director Prof. Bräuer (from left to right).*

Internships for pupils / Internships at the Fraunhofer IST

With the aim of introducing pupils to scientific topics and the work at a research institute, the Fraunhofer IST this year once again offered 3 girls and 5 boys the possibility of a pupil internship. Over a period of one to three weeks, each of the young researchers was provided with the opportunity of learning about the occupational profile of a physics laboratory assistant. Within the framework of the internship, the pupils were allowed to carry out diverse tests, experiments and measurement series together with the trainees, or to work on large coating facilities with which functional layers are produced using physical and chemical processes.

1

THE NETWORK OF COMPETENCE INDUSTRIAL PLASMA SURFACE TECHNOLOGY E. V. – INPLAS

The INPLAS e. V. Network of Competence, which is accredited as a network at the Federal Ministry for Economic Affairs and Energy (BMWi) in the "go-cluster" program, has its administrative office on the premises of the Fraunhofer IST in Braunschweig. The network currently has 54 members from industry and science (see. Fig. 1). Around 200 persons, 75 percent of whom are from industry, participate in the network activities.

The objective of the network is to raise awareness regarding plasma engineering and to support, promote, and accompany its development in the numerous application areas in their respective complexity. Several highlights of the many activities, projects, and events in 2019 are presented in the section below:

Application seminar "Activation – Functionalization"

The application seminar, which was organized by Tantec Plasma & Corona in cooperation with the scientific partner Fraunhofer IST and with the organizational support of the INPLAS office team, took place on 12th and 13th March 2019 and focused on the activation and functionalization of surfaces by means of atmospheric-pressure and low-pressure processes. The 31 participants, mainly users from the industry, were thereby provided with the opportunity of carrying out coating tests, under the professional guidance of Tantec and IST plasma experts, on sample materials which they had brought along.

International Conference on Sputter Technology & 10th International Conference on Fundamentals and Applications of HIPIMS (ST-HIPIMS Conference 2019)

The ST-HIPIMS Conference took place on 19th and 20th June 2019 in the Stadthalle in Braunschweig. For the first time, this year's conference included not only high-power impulse magnetron sputtering technology but also other sputtering techniques such as ion-beam and gas-flow sputtering. Around 100 international experts in these coating technologies were present. Current developments and applications, e. g. integrated sensor systems, flexible conductors, and broaching tools, were debated during presentations and discussion rounds and with the aid of posters. In addition, 20 industrial exhibitors presented their products and services in the field of vacuum and thin-film technology.

Workshop – Digitization, Big Data und Process Chains

On 8th May 2019, users, experts and interested parties came together in Berlin to discuss the topic of digitization and process chains in coating technology, in particular plasma technology. Speakers from the fields of eBusiness standards, process chains, data structures and data management presented possibilities and ways of storing and analyzing data and linking it to further production steps. An "open workshop" used practical examples to demonstrate the important points. The network INPLAS will continue to work on this topic and will offer project opportunities as well as workshops in order to define the task areas of digitization in plasma technology.

41st Meeting of the industry working group (IAK) "Tool Coatings and Cutting Materials"

Tool manufacturers and users, predominantly from industry, met at the 41st edition of the IAK in November 2019 in Braunschweig in order to exchange information on the latest devel-

opments and trends in the field of machining tools and their coatings. The spectrum of the presentation topics included hybrid machining of turbine components, hybrid manufacturing, hard-material coating development, simulation in the field of machining, HIPIMS in tool coating, the utilization of HIPIMS in tool coating as well as coatings for innovative tools and mechatronic systems. The IAK, organized by the partners IWF of the TU Berlin, Fraunhofer IPK, Fraunhofer IST and INPLAS e. V., takes place twice per year, in Berlin and Braunschweig.

14th INPLAS General Meeting

The 14th INPLAS General Meeting took place on 13th November 2019 in Venlo, Netherlands. IHI Hauzer Techno Coating B.V. hosted the meeting, which is an important instrument for the discussion and coordination of current and future network activities. One main focus at the 14th General Meeting was the presentation of a new cooperation format within the network in the form of the INPLAS joint projects. These are contract research projects without public funding, which offer uncomplicated access to topics, technology and/or fields of application. The first three planned projects, which are scheduled to start in the first quarter of 2020, address application-oriented focused issues in the fields of non-stick surfaces, digitization in the field of plasma diffusion technologies, and quantification of the CO_2 footprint of selected coating technologies. With a relatively low outlay, these joint projects can provide the ideal basis for industrial implementation and/or project funding.

INPLAS working groups

The WG "Innovative Plasma Sources and Processes", under the management team of Dr. Ulf Seyfert from VON ARDENNE GmbH, Matthias Nestler from scia systems GmbH and Dr. Anke Hellmich, Applied Materials GmbH & Co. KG, devoted their meetings in Berlin in May and in Venlo, Netherlands, in November to the status and development requirements in the field of plasma-enhanced chemical vapor deposition (PECVD) (see Fig. 2).

The WG "Tool Coatings", under the direction of Hanno Paschke, Fraunhofer IST, met at the IWF of the TU Berlin in May and at the Fraunhofer IST in Braunschweig in November. The participants hereby discussed e. g. the results of the project "Ecological and function-optimized pre-treatment chain for the plasma coating of complexly shaped cutting tools" (in short, "ÖkoClean"), a plasma fine-cleaning of machining tools, and new project ideas, thereby also taking into account Plasma Technology 4.0.

During the meetings of the WG "Combined Surface Technology", which is chaired by Dr. Petra Uhlmann, Leibniz Institute of Polymer Research, the participants addressed technologies for Cr(VI)-free plastic metallization and new applications of atmospheric-pressure plasmas using plasma jets. The meetings took place in February, at Coventya GmbH in Gütersloh, and in October, at Plasmatreat GmbH in Steinhagen.

The "Plasma4Life" working group, headed by Professor Peter Awakowicz, Ruhruniversität Bochum, Dr. Hendrikus Garritsen, Städtisches Klinikum Braunschweig, and Professor Wolfgang Viöl, HAWK University of Applied Sciences and Arts, Göttingen, met up at the Fraunhofer IST in Braunschweig in March. Presentations and discussions focused on developments and project opportunities in the field of bioeconomy.

CONTACT

Dipl.-Ing. Carola Brand
Managing Director
Phone +49 531 2155-574
carola.brand@inplas.de

www.inplas.de

PUBLICATIONS

Memberships

Arbeitsgemeinschaft Wärmebehandlung und Werkstofftechnik e. V.
www.awt-online.org

A.SPIRE
www.spire2030.eu

DECHEMA – Gesellschaft für Chemische Technik und Biotechnologie e. V.
www.dechema.de

Deutsche Gesellschaft für Elektronenmikroskopie e. V.
www.dge-homepage.de

Deutsche Gesellschaft für Galvano- und Oberflächentechnik e. V.
www.dgo-online.de

Deutsche Gesellschaft für Materialkunde e. V.
www.dgm.de

Deutsche Glastechnische Gesellschaft (DGG)
www.hvg-dgg.de

Deutsches Institut für Normung e. V. (DIN)
www.din.de

Europäische Forschungsgesellschaft für Blechverarbeitung e. V. (EFB)
www.efb.de

Europäische Forschungsgesellschaft Dünne Schichten e. V. (EFDS)
www.efds.org

Europäisches Komitee für Normung (CEN)
www.cen.eu

European Factories of the Future Research Association (EFFRA)
www.effra.eu

European Joint Committee on Plasma and Ion Surface Engineering (EJC/PISE)
www.ejc-pise.org

Fachverband Angewandte Photokatalyse (FAP)
www.vdmi.de/deutsch/produkte/angewandte-photokatalyse.html

F.O.M. Forschungsvereinigung Feinmechanik, Optik und Medizintechnik e. V.
www.forschung-fom.de

ForschungRegion Braunschweig e. V.
www.forschungregion-braunschweig.de

Forschungsgemeinschaft Werkzeug und Werkstoffe e. V. (FGW)
www.fgw.de

Forschungsvereinigung Räumliche Elektronische Baugruppen 3-D MID e. V.
www.3d-mid.de

Fraunhofer-Allianz Adaptronik
www.adaptronik.fraunhofer.de

Fraunhofer-Allianz autoMOBILproduktion
www.automobil.fraunhofer.de

Fraunhofer-Allianz Batterien
www.batterien.fraunhofer.de

Fraunhofer-Allianz Generative Fertigung
www.generativ.fraunhofer.de

Fraunhofer-Allianz Leichtbau
www.leichtbau.fraunhofer.de

Fraunhofer-Allianz Numerische Simulation von Produkten, Prozessen
www.nusim.fraunhofer.de

Fraunhofer-Allianz Reinigungstechnik
www.allianz-reinigungstechnik.de

Fraunhofer-Allianz Space
www.space.fraunhofer.de

Fraunhofer-Allianz SysWasser
www.syswasser.de

Fraunhofer-Allianz Textil
www.textil.fraunhofer.de

Fraunhofer-Netzwerk Elektrochemie
www.elektrochemie.fraunhofer.de

Fraunhofer-Netzwerk Nachhaltigkeit
www.fraunhofer.de/de/ueber-fraunhofer/corporate-responsibility/governance/nachhaltigkeit/fraunhofer-netzwerk-nachhaltigkeit.html

Fraunhofer-Verbund Light & Surfaces
www.light-and-surfaces.fraunhofer.de

German Flatpanel Display Forum DFF
www.displayforum.de

German Water Partnership
www.germanwaterpartnership.de

Göttinger Research Council
www.uni-goettingen.de

Innovationsnetzwerk Niedersachsen
www.innovationsnetzwerk-niedersachsen.de

International Council for Coatings on Glass e. V.
www.iccg.eu

Kompetenznetz Industrielle Plasma-Oberflächentechnik e. V. (INPLAS)
www.inplas.de

Materials Valley e. V.
www.materials-valley.de

Measurement Valley e. V.
www.measurement-valley.de

Nanotechnologie Kompetenzzentrum Ultrapräzise Oberflächenbearbeitung CC UPOB e. V.
www.upob.de

NANOfutures European Technology Integration and Innovation Platform (ETIP) in Nanotechnology
www.nanofutures.eu

Optence e. V.
www.optence.de

Open Hybrid LabFactory e. V.
www.open-hybrid-labfactory.de

PhotonicNet GmbH – Kompetenznetz Optische Technologien
www.photonicnet.de

Plasma Germany
www.plasmagermany.org

Spectaris – Verband der Hightech-Industrie
www.spectaris.de

Surface.net – Kompetenznetzwerk für Oberflächentechnik e. V.
www.netzwerk-surface.net

Wissens- und Innovations-Netzwerk Polymertechnik (WIP)
www.wip-kunststoffe.de

Zentrum für Mikroproduktion e. V. (ZeMPro)
www.microcompany.de

Board memberships

Abraham, T.: Fachausschuss FA 10 »Funktionelle Schichten« der Arbeitsgemeinschaft Wärmebehandlung und Werkstofftechnik e. V. AWT, Mitglied.

Bandorf, R.: Europäische Forschungsgesellschaft Dünne Schichten e. V. (EFDS), Beirat.

Bandorf, R.: Forschungsvereinigung Räumliche Elektronische Baugruppen 3-D MID e. V., Mitglied.

Bandorf, R.: International Conference on HIPIMS, Conference Chairman.

Bandorf, R.: Society of Vacuum Coaters, Dozent.

Bandorf, R.: Society of Vacuum Coaters, Member Board of Directors.

Bandorf, R.: Society of Vacuum Coaters, Program Chairman.

Bandorf, R.: Society of Vacuum Coaters, Session Chairman.

Bandorf, R.: Society of Vacuum Coaters, Volunteer Mentor.

Baron, S.: VDI-Richtlinien-Fachausschuss »CVD-Diamant-Werkzeuge«, Mitglied.

Bewilogua, K.: Programmkomitee EFDS-Workshop Haft- und Antihaftschichten (Januar 2019).

Brand, C.: Arbeitgeberverband Region Braunschweig, Mitglied.

Brand, C.: Europäische Forschungsgesellschaft Dünne Schichten e. V. (EFDS), Mitglied.

Brand, C.: Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Geschäftsführerin.

Brand, C.: Plasma Germany, Mitglied des Koordinierungs-ausschusses.

Brand, J.: Gesellschaft für Tribologie (GfT), Mitglied.

Brand, J.: International Colloquium Tribology, Tribology and Lubrication Engineering, Mitglied im Programme Planning Committee.

Bräuer, G.: International Conference on Coatings on Glass and Plastics (ICCG), Vorsitzender des Organisationskomitees.

Bräuer, G.: International Council for Coatings on Glass (ICCG) e. V., Mitglied des Vorstands.

Bräuer, G.: Institut für Solarenergieforschung, Mitglied des Beirats.

Bräuer, G.: Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Vorstandsvorsitzender.

Bräuer, G.: Zeitschrift »Vakuum in Forschung und Praxis«, Mitglied des Kuratoriums.

Dietz, A.: Arbeitsgemeinschaft Elektrochemischer Forschung (AGEF), Mitglied.

Dietz, A.: Deutsche Gesellschaft für Galvano- und Oberflächentechnik e. V. (DGO), Mitglied des Vorstands.

Dietz, A.: EARTO- European Association of Research and Technology Organisations, Working Group Space Research, Mitglied.

Dietz, A.: Fachausschuss »Forschung« der DGO, Mitglied.

Dietz, A.: Fachausschuss »Kombinationsschichten« der DGO, Mitglied.

Eichler, M.: Conference on Wafer Bonding for Microsystems 3D- and Wafer Level Integration, Steering Committee.

Eichler, M.: Plasma Surfaces in Healthcare and Industry, International Scientific Committee.

Gäbler, J.: DIN Deutsches Institut für Normung e. V., Normenausschuss NA 062 Materialprüfung, Arbeitsausschuss 062-01-72 »Chemische und elektrochemische Überzüge«, Mitglied.

Gäbler, J.: DIN Deutsches Institut für Normung e. V., Normenausschuss NA 062 Materialprüfung, Arbeitsausschuss 062-01-64 »Kohlenstoffschichten und keramische Hartstoffschichten«, stellvertretender Obmann.

Gäbler, J.: European Technology Platform for Advanced Materials and Technologies EuMaT, Mitglied.

Gäbler, J.: European Technology Platform NANOfutures, Mitglied.

Gäbler, J.: ISO Technical Committee TC 107 »Metallic and other inorganic coatings«, Mitglied.

Gäbler, J.: VDI-Richtlinien-Fachausschuss »CVD-Diamant-Werkzeuge«, Mitglied.

Gerdes, H.: Society of Vacuum Coaters, Dozent.

Gerdes, H.: Society of Vacuum Coaters, Session Chairman.

Gerdes, H.: VDI/VDE-GMA Fachausschuss 2.11 »Elektrische Messverfahren; DMS-Messtechnik«, Mitglied.

Herrmann, C.: Battery LabFactory Braunschweig (BLB), Vorstandsmitglied.

Herrmann, C.: Internationale Akademie für Produktionstechnik (CIRP), Mitglied.

Herrmann, C.: Niedersächsisches Forschungszentrum Fahrzeugtechnik NFF, assoziiertes Mitglied.

Herrmann, C.: Niedersächsisches Forschungszentrum für Luftfahrt NFL, Mitglied.

Herrmann, C.: Open Hybrid LabFactory OHLF, Arbeitskreisleiter Umwelt und Recycling.

Herrmann, C.: Zentrums für Pharmaverfahrenstechnik PVZ, Mitglied.

Keunecke, M.: EFDS-Fachausschuss »Tribologische Schichten«, Mitglied.

Keunecke, M.: OTTI-Fachforum PVD- und CVD-Beschichtungsverfahren für tribologische Systeme, Fachliche Leitung.

Keunecke, M.: SAE International, Mitglied.

Keunecke, M.: Society of Vacuum Coaters, Dozent.

Keunecke, M.: Society of Vacuum Coaters, Session Chairman.

Klages, C.-P.: Europäische Forschungsgesellschaft Dünne Schichten e. V. (EFDS), Mitglied des wissenschaftlichen Beirats.

Lachmann, K.: COST Action MP1101 »Biomedical Applications of Atmospheric Pressure Plasma Technology«, Management Committee, Substitute.

Neumann, F.: DIN Deutsches Institut für Normung e. V., Normenausschuss 062 Materialprüfung, Arbeitsausschuss NA 062-02-93 AA »Photokatalyse«, Stellvertretender Obmann.

Neumann, F.: DIN Deutsches Institut für Normung e. V., Normenausschuss 062 Materialprüfung, Arbeitsausschuss NA 062-02-93 AA »Photokatalyse«, Leitung des Arbeitskreises »Photokatalytische Selbstreinigung«.

Neumann, F.: Europäisches Komitee für Normung, CEN/TC 386 »Photocatalysis«, Delegierter des Technischen Komitees.

Neumann, F.: Europäisches Komitee für Normung, CEN/TC 386 »Photocatalysis«, Mitglied.

Neumann, F.: Fachverband Angewandte Photokatalyse (FAP), Forschungsausschuss, Mitglied.

Neumann, F.: Ostfalia Hochschule für angewandte Wissenschaften, Fakultät Versorgungstechnik, Studiengang »Bio- und Umwelttechnik«, Mitglied des Beirats.

Neumann, F.: ISO Normenausschuss TC 206/WG 9 »Photocatalysis«, Mitglied.

Paschke, H.: Fachausschuss FA10 »Funktionelle Schichten« der Arbeitsgemeinschaft Wärmebehandlung und Werkstofftechnik e. V. AWT, Mitglied.

Paschke, H.: Industriearbeitskreis »Werkzeugbeschichtungen und Schneidstoffe«, Leitung.

Paschke, H.: Kompetenznetzwerk für Oberflächentechnik »netzwerk-surface.net«, wissenschaftlicher Beirat (Sprecher).

Paschke, H.: Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Arbeitsgruppenleiter Werkzeugbeschichtungen.

Schäfer, L.: Beirat der CONDIAS GmbH, Mitglied.

Schäfer, L.: Industriearbeitskreis »Werkzeugbeschichtungen und Schneidstoffe«, Mitglied.

Schäfer, L.: Kompetenznetz Optence e. V., »Networking in Photonics«, Mitglied.

Schäfer, L.: Nanotechnologie-Kompetenzzentrum Ultrapräzise Oberflächenbearbeitung CC UPOB e. V., Mitglied.

Schäfer, L.: VDI-Richtlinien-Fachausschuss »CVD-Diamant-Werkzeuge«, Mitglied.

Sittinger, V.: Europäische Forschungsgesellschaft Dünne Schichten e. V. (EFDS), Workshop »Dünnschichttechnologie für Energiesysteme, V2017«, Chairman, Programmkomitee.

Sittinger, V.: European Photovoltaic Solar Energy Conference and Exhibition, Scientific Committee Member, Paper Review Expert.

Sittinger, V.: Society of Vacuum Coaters, Program Chairman.

Sittinger, V.: Society of Vacuum Coaters, Session Chairman.

Sittinger, V.: European Materials Research Society (E-MRS) 2019 Spring Meeting, NANO-FUNCTIONAL MATERIALS, Scientific Committee Member.

Stein, C.: Society of Vacuum Coaters, Dozent.

Stein, C.: Society of Vacuum Coaters, Session Chairman.

Stein, C.: VDI-Arbeitskreis »Schneidstoffanwendungen«, Mitglied.

Thomas, M.: Anwenderkreis Atmosphärendruckplasma (AK-ADP), Mitglied.

Thomas, M.: Arbeitsgruppe »Plasma4Life« INPLAS e.V., Mitglied.

Thomas, M.: DECHEMA – Gesellschaft für Chemische Technik und Biotechnologie e. V., Mitglied.

Thomas, M.: European Joint Committee on Plasma and Ion Surface Engineering (EJC / PISE), Chairman.

Thomas, M.: International Conference on Plasma Surface Engineering, International Program Committee IPC, Mitglied.

Thomas, M.: Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Vorstandsmitglied.

Thomas, M.: Plasma Germany, Koordinierungsausschuss, Mitglied.

Vergöhl, M.: Europäische Forschungsvereinigung für dünne Schichten e.V. (EFDS), Mitglied des Vorstands.

Vergöhl, M.: Europäische Forschungsvereinigung für dünne Schichten e.V. (EFDS), stellvertretende Leitung des Fachausschusses »Beschichtungstechnologien für optische und elektronische Funktionalisierung«.

Vergöhl, M.: Lenkungskreis »Photonik« des VDMA, Mitglied.

Vergöhl, M.: Optical Society (OSA), Dozent.

Viöl, W.: Amt für regionale Landesentwicklung Braunschweig, Mitglied Fachbeirat Südniedersachsen.

Viöl, W.: Bundesministerium für Bildung und Forschung BMBF, Mitglied des Programmbeirats.

Viöl, W.: Deutsche Gesellschaft für Plasmatechnologie e. V. DGPT, Mitglied des Vorstands.

Viöl, W.: DFG Fachkollegien, Mitglied.

Viöl, W.: Gesellschaft Deutscher Naturforscher und Ärzte e. V. GDNÄ, Mitglied im Fachbeirat.

Viöl, W.: HAWK Hochschule für angewandte Wissenschaft und Kunst Hildesheim / Holzminden / Göttingen, Vizepräsident für Forschung und Transfer.

Viöl, W.: Hochschulrektorenkonferenz Forschungskommission Fachhochschulen.

Viöl, W.: Kompetenznetz für Nachhaltige Holznutzung (NHN) e. V., Vorstandsmitglied.

Viöl, W.: Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Kassenwart.

Viöl, W.: Nationales Zentrum für Plasmamedizin, Vorstandsmitglied.

Viöl, W.: Spectaris – Verband der Hightech-Industrie, Fachverband Photonik, Mitglied des Lenkungsausschusses.

Publications

Abramovic, I.; Pavone, A.; Moseev, D.; Lopes Cardozo, N. L.; Salewski, M.; Laqua, H. P.; Stejner, M.; Stange, T.; Marsen, S.; Nielsen, S. K.; Jensen, T.; Kasparek, W.; and W7-X Team; Keunecke, M. (2019): Forward modeling of collective Thomson scattering for Wendelstein 7-X plasmas. Electrostatic approximation. In: Review of scientific instruments 90, 023501 (12 pp.). DOI: 10.1063/1.5048361.

An, S.; Fricke, K.; Riemer, H.; Petersen, M.; Paschke, H.; Quade, A.; Ihrke, R.; Weltmann, K.-D.; Fröhlich, M. (2019): Vorbehandlung und Reinigung von Werkzeugoberflächen durch plasmaelektrolytisches Polieren zur Verbesserung der Haftung von Verschleissschutzschichten. In: Atmosphärische Plasmen, S. 69 – 79.

Badorreck, H.; Steinecke, M.; Jensen, L.; Ristau, D.; Jupé, M.; Müller, J.; Tonneau, R.; Moskovkin, P.; Lucas, S.; Pflug, A.; Grinevičiūtė, L.; Selskis, A.; Tolenis, T. (2019): Correlation of structural and optical properties using virtual materials analysis. In: Optics express 27 (16), pp. 22209 – 22225. DOI: 10.1364/OE.27.022209.

Bandorf, R. (2019): Hochionisierte Abscheideverfahren für Hartstoffschichten auf Kohlenstoffbasis. In: Journal für Oberflächentechnik 59 (Special Galvanotechnik), S. 29 – 31. DOI: 10.1007/s35144-019-0068-7.

Bandorf, R.; Biehl, S.; Brand, J. (2019): Oberflächenintegrierte Dünnschichtsensoren. In: Journal für Oberflächentechnik (Article in Press. First online: 30 December 2019. DOI: 10.1007/s35144-019-0446-1, 3 pp.). DOI: 10.1007/s35144-019-0446-1.

Biehl, S.; Meyer-Kornblum, E.; Paetsch, N.; Bräuer, G. (2019): Sensormodule für die optimierte Herstellung von naturfaserverstärkten Kunststoffen im Spritzguss. Symposium für Smarte Strukturen und Systeme <2019, Darmstadt>. In: Smarte Strukturen und Systeme, S. 91 – 101.

Bittner, F.; Bellmann, M.; Shamsuyeva, M.; Endres, H.-J.; Viöl, W. (2019): Improving the durability of bio hybrid fiber reinforced plastics by plasma treatment. In: Technologies for economical and functional lightweight design, pp. 201 – 212.

Bräuer, G.; Brand, J.; Britze, C.; Dietz, A.; Kondruweit, S.; Thomas, M.; Vergöhl, M. (2019): Für den weitesten Weg : Schichten im All. Mittels Galvanik und Sputtern hergestellte Schichten erfüllen extreme Anforderungen. In: Vakuum in Forschung und Praxis 31 (6), S. 26 – 31. DOI: 10.1002/vipr.201900729.

Brune, T.; Garritsen, H. S. P. (2019): Erkrankungen des Blutes: Hämotherapie. In: Neonatologie : die Medizin des Früh- und Reifgeborenen, S. 362 – 375.

Dmitriev, A. M.; Pflug, A.; und viele weitere (2019): RF plasma cleaning of water-cooled mirror equipped with notch filter based on shorted λ/4 line. In: Fusion engineering and design 164, Part A, pp. 1390 – 1393. DOI: 10.1016/j.fusengdes.2019.02.090.

Dröder, K.; Hoffmeister, H.-W.; Baron, S.; Gäbler, J.; Höfer, M. (2019): Einsatzverhalten strukturierter CVD-Diamantbeschichteter Honleisten. In: Jahrbuch Schleifen, Honen, Läppen und Polieren, S. 284 – 297.

Emmert, S.; Boeckmann, L.; Fischer, T.; Bernhardt, T.; Borchardt, T.; Viöl, W.; Wahl, P.; Wandke, D.; Metelmann, H.; Masur, K.; Bekeschus, S.; Wödtke, T. v.; Weltmann, K.-D. (2019): Plasmamedizin für Hauterkrankungen: Wunden und Tumoren. In: Atmosphärische Plasmen, S. 213 – 225.

Emmrich, S.; Plogmeyer, M.; Bartel, D. (2019): Dünnschichtsensorik zur ortsauflösenden Temperaturmessung in geschmierten Wälzkontakten. Tribologie-Fachtagung <60, 2019, Göttingen>. In: Reibung, Schmierung und Verschleiss: Forschung und praktische Anwendungen, 04/1, 6 S.

Flegler, F.; Groche, P.; Abraham, T.; Bräuer, G. (2019): Extremely smooth. How smooth surfaces enable dry and boundary lubricated forming of aluminum; WGP Jahreskongress <9, 2019, Hamburg>. In: Production at the leading edge of technology, pp. 239 – 247.

Gelker, M.; Mrotzek, J.; Ichter, A.; Müller-Goymann, C. C.; Viöl, W. (2019): Influence of pulse characteristics and power density on stratum corneum permeabilization by dielectric barrier discharge. In: Biochimica et biophysica acta / General subjects 1863 (10), pp. 1513 - 1523. DOI: 10.1016/j.bbagen.2019.05.014.

Grein, M.; Bandorf, R.; Schiffmann, K.; Bräuer, G. (2019): Material structure and piezoresistive properties of niobium containing diamond-like-carbon films. In: Surface and coatings technology 357, pp. 273 – 279. DOI: 10.1016/j.surfcoat.2018.10.008.

Grein, M.; Gerstenberg, J.; Heide, C. v. d.; Bandorf, R.; Bräuer, G.; Dietzel, A. (2019): Niobium-containing DLC coatings on various substrates for strain gauges. In: Coatings 9 (7), 417, 11 pp. DOI: 10.3390/coatings9070417.

Hahn, I.; Siebert, S.; Theisen, W.; Paschke, H. (2019): Niedertemperatur-Plasmanitrieren zur Optimierung der Tribokorrosionseigenschaften nichtrostender Stähle für die Anwendung als Wälzlager. Tribologie-Fachtagung <60, 2019, Göttingen>. In: Reibung, Schmierung und Verschleiss: Forschung und praktische Anwendungen, FF05/1, 9 S.

Herrmann, A.; Dohse, A.; Köther, J.; Erguen, Y.; Thomas, M. (2019): New materials equipped with functional surface features via novel composite coatings deposited using atmospheric PECVD. 9 – 14 June 2019, Naples, Italy; International Symposium on Plasma Chemistry <24, 2019, Naples>. In: ISPC 24 Proceedings, 311, 3 pp. Online verfügbar unter https://www.ispc-conference.org/ispcproc/ispc24/311.pdf.

Herrmann, C.; Leiden, A.; Cerdas, F.; Bandorf, R.; Vergöhl, M. (2019): Sustainability through data-driven computational production and life cycle engineering. Society of Vacuum Coaters Annual Technical Conference <62, 2019, Long Beach, Calif.>. In: 62th Annual Technical Conference Proceedings. Part One ([KONGRESSFOLGE] Annual technical conference / Society of Vacuum Coaters), pp. 17 – 28. Online verfügbar unter https://www.flipsnack.com/svcdigitalpublications/2019-proceedings-part-1.html.

Höft, S.; Grahn, S.; Bialuch, I.; Augustin, W.; Scholl, S. (2019): Low-fouling heat exchanger for biofuel usage in combined heat and power units. In: Heat transfer engineering (Article in press. Published online: 22 Jan 2019. DOI: 10.1080/01457632.2018.1540452).

Justianto, M.; Harig, T.; Höfer, M.; Sittinger, V. (2019): Silicon films for heterojunction solar cells by hot-wire CVD. International Conference on Crystalline Silicon Photovoltaics <9, 2019, Leuven>. In: SiliconPV 2019, the 9th International Conference on Crystalline Silicon Photovoltaics (AIP conference proceedings; 2147), 050006, 7 pp.

Justianto, M.; Höfer, M.; Harig, T.; Sittinger, V. (2019): Deposition of surface passivation layers for silicon heterojunction solar cells by hot-wire CVD. Society of Vacuum Coaters Annual Technical Conference <61, 2018, Orlando, Fla.>. In: SVC bulletin (Fall/Winter 2019), pp. 58 – 63. DOI: 10.14332/svc18.proc.0032.

King, H.; Pflug, A.; Ortner, K.; Höfer, M.; Harig, T.; Sittinger, V. (2019): DSMC – simulation of the influence of hydrogen addition on the properties of silicon deposited by HWCVD. In: Surface and coatings technology 379, 125035, 6 pp. DOI: 10.1016/j.surfcoat.2019.125035.

Lachmann, K.; Duckstein, R.; Herrmann, A.; Dohse, A.; Jänsch, M.; Thomas, M. (2019): Funktionelle Schichten mittels DBE zur Steuerung der Haftung. In: Atmosphärische Plasmen, S. 142 – 149.

Landgrebe, D.; Demmler, M.; Albert, A.; Schieck, F.; Weber, M. (2019): Technology development and tool concepts for high-temperature forming of titanium. In: Proceedings of the ASME International Mechanical Engineering Congress and Exposition, 2018. Volume 2: Advanced Manufacturing, paper no. IMECE2018-86660, V002T02A027, 11 pp.

Lehm, A.; Romstedt, D.; Schoenberner, V.; Meyer, H. T.; Eichler, M. (2019): Adhesive-free bonding of web-like plastic-metal combinations at low temperatures. Symposium on Composites <22, 2019, Kaiserslautern>. In: 22nd Symposium on Composites (Key engineering materials; 809), pp. 392 – 397.

Linss, V.; Bivour, M.; Iwata, H.; Ortner, K. (2019): Comparison of low damage sputter deposition techniques to enable the application of very thin a-Si passivation films. International Conference on Crystalline Silicon Photovoltaics <9, 2019, Leuven>. In: SiliconPV 2019, the 9th International Conference on Crystalline Silicon Photovoltaics (AIP conference proceedings; 2147), 040009, 7 pp.

Mathioudaki, S.; Vandenabeele, C.; Tonneau, R.; Pflug, A.; Lucas, S. (2019): Characterization of a pulsed low pressure argon discharge in a cylindrical magnetron reactor by plasma diagnostic and 3D plasma modeling. In: Journal of vacuum science & technology A : JVST 37 (3), 031301, 13 pp. DOI: 10.1116/1.5064690.

Maurer, V.; Frank, C.; Porsiel, J. C.; Zellmer, S.; Garnweitner, G.; Stosch, R.: Step-by-step monitoring of a magnetic and SERS-active immunosensor assembly for purification and detection of tau protein. In: Journal of biophotonics (Article in Press. First published: 13 November 2019. DOI: 10.1002/jbio.201960090, 10 pp.)

Mejauschek, M. (2019): Vorhersage von Plasmanitrierergebnissen. Projekt „ProgPlas“. In: ZVO-Report (3), S. 55. Online verfügbar unter https://www.zvo.org/fileadmin/zvo/ZVOreport/2019_DS/ZVO-Report_03-2019_X.pdf.

Muydinov, R.; Steigert, A.; Wollgarten, M.; Michalowski, P. P.; Bloeck, U.; Pflug, A.; Erfurt, D.; Klenk, R.; Körner, S.; Lauermann, I.; Szyszka, B. (2019): Crystallisation phenomena of In_2O_3:H films. In: Materials 12 (2), 266, 20 pp. DOI: 10.3390/ma12020266.

Neubert, T. (2019): 3D-gedruckte Polymere funktional beschichtet. Geeignete Aktivierung notwendig. In: Plastverarbeiter (2), S. 30 – 31. Online verfügbar unter https://www.plastverarbeiter.de/83031/3d-gedruckte-polymere-funktional-beschichtet/.

Neubert, T.; Borris, J.; Lachmann, K. (2019): Funktionelle Oberflächen für 3-D-gedruckte Polymere. In: Nachrichten aus der Chemie 67 (6), S. 28 – 29. DOI: 10.1002/nadc.20194086867.

Neubert, T.; Lachmann, K.; Zeren, V.; Schlüter, F.; Scopece, P.; Patelli, A.; Thomas, M. (2019): Influence of the substrate temperature on the layer properties made by an atmospheric plasma jet using different precursors. International Symposium on Plasma Chemistry <24, 2019, Naples>. In: ISPC 24 Proceedings, 373, 4 p. Online verfügbar unter https://www.ispc-conference.org/ispcproc/ispc24/373.pdf.

Neubert, T.; Zeren, V.; Steinberg, C.; Thomas, M.; Cámara Torres, M.; Scopece, P.; Howitz, S.; Lachmann, K. (2019): Funktionale Beschichtungen auf 3D-gedruckten Polymerimplantatstrukturen. Interdisziplinärer Kongress für Technik und Hygiene im Krankenhaus <20, 2019, Würzburg>. In: Kompendium Technik und Hygiene im Krankenhaus 2019, S. 22 – 25.

Nienhaus, A.; Bräuer, G.; Paschke, H.; Stangier, D.; Tillmann, W.; Paulus, M.; Sternemann, C. (2019): Nanocomposite PECVD multiphase coatings for wear reduction under thermal load conditions. Niedersächsisches Symposium Materialtechnik <3, 2019, Clausthal-Zellerfeld>. In: Tagungsband 3. Niedersächsisches Symposium Materialtechnik (Fortschrittsberichte der Materialforschung und Werkstofftechnik; 7), pp. 511 – 522.

Paschke, H.; Mejauschek, M.; Weber, M.; Brunotte, K.; Siegmund, M.; Peddinghaus, J.; Lenz, D.; Bräuer, G.; Behrens, B.-A.; Dültgen, P. (2019): Life time enhancement of forging dies with tailored diffusion treatments. Tooling Conference & Exhibition <11, 2019, Aachen>. In: Tooling 2019 Conference & Exhibition, 7 S.

Plogmeyer, M.; Biehl, S.; Paetsch, N.; Bräuer, G. (2019): Dünnschichtsensoren zur Temperaturmessung im Mischreibungskontakt. Symposium für Smarte Strukturen und Systeme <2019, Darmstadt>. In: Smarte Strukturen und Systeme, S. 161 – 168.

Pribbenow, J.; Landgraf, P.; Mejauschek, M.; Grund, T.; Lampke, T.; Bräuer, G. (2019): Prognosetool für Plasmanitrierprozesse zur Randschichtbehandlung von Werkzeugen und Bauteilen. In: Galvanotechnik 110 (8), S. 1473 – 1474.

Pribbenow, J.; Mejauschek, M.; Landgraf, P.; Grund, T.; Bräuer, G.; Lampke, T. (2019): Neural network for prediction of hardness profiles for steel alloys after plasma nitriding. In: IOP conference series (480), 012019, 6 pp. Online verfügbar unter https://iopscience.iop.org/article/10.1088/1757-899X/480/1/012019/pdf.

Rickert, J.; Drachenfels, N. v.; Cerdas, F.; Herrmann, C. (2019): Integration of product entropy and LCA to screen the potential environmental impacts of complex product systems at the end-of-life stage. In: CIRP annals 68, pp. 25 – 28. DOI: 10.1016/j.cirp.2019.04.029.

Schäfer, L.; Biehl, S.; Pflug, A.; Vergöhl, M. (2019): Fabrication of precision optical components and thin film sensors by integrated processes. Vacuum Coating Conference Shenzen VCCS 2019, 22.11.2019, Shenzen, China; Vacuum Coating Conference Shenzen <5, 2019, Shenzen>. Online verfügbar unter http://fhgonline.fraunhofer.de/bibliotheken/wkiist/SchaeferVCCS2019.pdf.

Schiffmann, K. (2019): SIMS depth profile analysis of tribological coatings on curved surfaces. Influence of ion impact angle and take-off angle on ion yield and on the quantitative analysis of chemical composition. In: Surface and interface analysis 51 (7), pp. 703 – 711. DOI: 10.1002/sia.6641.

Schiffmann, K.; Steinberg, C. (2019): EPMA-Analyse dünner PVD- und CVD-Schichten. Grundlagen und Beispiele aus der industriellen Praxis. In: Vakuum in Forschung und Praxis 31 (3), S. 26 – 36. DOI: 10.1002/vipr.201900714.

Schulze, C.; Blume, S.; Siemon, L.; Herrmann, C.; Thiede, S. (2019): Towards energy flexible and energy self-sufficient manufacturing systems. CIRP Conference on Manufacturing Systems <52, 2019, Ljubljana>. In: Procedia CIRP 81, pp. 683 – 688. DOI: 10.1016/j.procir.2019.03.176.

Schütte, T.; Neiss, P.; Rieke, J. E.; Gerdes, H.; Bandorf, R.; Vergöhl, M.; Bräuer, G. (2019): How to run a reliable reactive HIPIMS process over a target lifetime. Society of Vacuum Coaters Annual Technical Conference <62, 2019, Long Beach, Calif.>. In: 62th Annual Technical Conference Proceedings. Part One ([KONGRESSFOLGE] Annual technical conference / Society of Vacuum Coaters), pp. 323 – 328. Online verfügbar unter https://www.flipsnack.com/svcdigitalpublications/2019-proceedings-part-1.html.

Sittinger, V.; Schäfer, L.; Gäbler, J.; Höfer, M.; Bräuer, G.; Bond, R. J.; Matthée, T.; Brackemeyer, D.; Wilsenach, J.; Woods, M. (2019): Self-sustaining cleaning technology for safe water supply and management in rural African areas – SafeWaterAfrica. Society of Vacuum Coaters Annual Technical Conference <62, 2019, Long Beach, Calif.>. In: 62th Annual Technical Conference Proceedings. Part One ([KONGRESSFOLGE] Annual technical conference / Society of Vacuum Coaters), pp. 69 – 76. Online verfügbar unter https://www.flipsnack.com/svcdigitalpublications/2019-proceedings-part-1.html.

Thomas, M.; Herrmann, A.; Dohse, A.; Borris, J.; Weidlich, E. R. (2019): Printing of µm structures with nano inks using a novel combination of high-resolution plasma printing and subsequent rotogravure printing. In: Plasma processes and polymers 16 (9), 11 pp. DOI: 10.1002/ppap.201900080.

Uhlmann, E.; Barth, E.; Gäbler, J.; Höfer, M. (2019): CVD-Diamantwerkzeuge mit SiC-Zwischenschicht. In: wt Werkstattstechnik online (11/12), S. 857 – 861.

Uhlmann, E.; Riemer, H.; An, S.; Fröhlich, M.; Paschke, H.; Petersen, M. (2019): Ecological and functional optimization of the pretreatment process for plasma based coatings of cutting tools. Global Conference on Sustainable Manufacturing <16, 2018, Lexington>. In: Procedia manufacturing 33, pp. 618 – 624. DOI: 10.1016/j.promfg.2019.04.077.

Vergöhl, M.; Britze, C.; Bruns, S.; Pflug, A.; Zimara, J.; Schäfer, B.; Mann, K.; Kirschner, V. (2019): Uniformity and wavefront control of optical filters. International Conference on Space Optics <12, 2018, Chania>. In: International Conference on Space Optics – ICSO 2018 (Proceedings of SPIE; 11180). Online verfügbar unter https://www.spiedigitallibrary.org/proceedings/Download?fullDOI=10.1117%2F12.2536069.

Wang, X.; Mayrhofer, L.; Höfer, M.; Estrade, S.; López-Conesa, L.; Zhou, H.; Lin, Y.; Peiró, F.; Fan, Z.; Shen, H.; Schäfer, L.; Moseler, M.; Bräuer, G.; Waag, A. (2019): Facile and efficient atomic hydrogenation enabled black TiO_2 with enhanced photo-electrochemical activity via a favorably low-energy-barrier pathway. In: Advanced energy materials 9 (33), 1900725, 14 pp. DOI: 10.1002/aenm.201900725.

Lectures and posters

Bandorf, R.; Märtins, D.; Grein, M.; Hellmers, S.; Rösler, J.; Bräuer, G.: HIPIMS Deposition of Advanced DLC Coatings for Sensor and Tribological applications. 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April – 2. Mai 2019 (Vortrag).

Bandorf, R.; Keunecke, M.; Bialuch, I.; Brand, J.; Sittinger, V.; Schäfer, L.; Bräuer, G.: Diamond and Diamond-Like Carbon (DLC) Coatings Technologies and Applications. Carbon Taiwan, Taichung, TW, 2. – 3. August 2019 (Keynote Vortrag).

Bandorf, R.: Optical Coating Systems and Manufacturing Equipment, Advanced Optical Coating Seminar, Feng Chia University, Taichung, Taiwan, 29. November 2019 (Vortrag).

Baron, S.: Einsatzverhalten strukturierter CVD-Diamantbeschichteter Honleisten, Industriearbeitskreis Werkzeugbeschichtungen und Schneidstoffe, Berlin, 7. Mai 2019 (Vortrag).

Bräuer, G.: Sputtering technology – recent developments and application examples, 3. International Symposium on Coatings on Glass and Plastics, Tokyo, Japan, 4. – 5. April 2019 (Vortrag).

Bräuer, G.: Some recent developments in sputter technology, Glass Performance Days, Tampere, Finnland, 26. Juni 2019 (Vortrag)

Bräuer, G.: Sputtering as key for innovations – some recent results from R+D, 12th Asian-European International Conference on Plasma Surface Engineering AEPSE, Jeju, Südkorea, 03. September 2019 (Vortrag)

Bräuer, G.: Sputtering as key for innovations – some recent results from R+D, International Conference Power Electronics for Plasma Engineering PE2, Zielonka/Warschau, Polen, 24.–26. September 2019 (Vortrag).

Blume, S.; Dilger, N.; Herrmann C.: From Li-ion Batteries to All-Solid-State Batteries: A Life Cycle Comparison, International Battery Production Conference IBPC 2019, Braunschweig, 4.–6. November 2019 (Vortrag).

Dietz, A.; Moustafa, E.: Fly me to the moon – Und dann? Extraterrestrische Produktionsverfahren, 21. Werkstofftechnisches Kolloquium, Chemnitz, 6.–7. März 2019 (Eingeladener Vortrag).

Dietz, A.: Generative Fertigung: Herausforderungen und Chancen für die Oberflächentechnik, 41. Ulmer Gespräch der DGO, Ulm, 8.–9. Mai 2019 (Eingeladener Vortrag).

Dietz, A.; Moustafa, E.: Fly me to the moon – Und dann? Extraterrestrische Produktionsverfahren, 41. Ulmer Gespräch der DGO, Ulm, 8.–9. Mai 2019 (Eingeladener Vortrag).

Dietz, A.: Beschichtete Bauteile für Weltraumanwendungen, DLR – Workshop Additive Fertigung in der Raumfahrt, Bonn, 28. Mai 2019 (Vortrag).

Dietz, A.: Oberflächentechnik für die generative Fertigung von Polymerbauteilen, 22. Symposium Verbundwerkstoffe und Werkstoffverbunde der DGM, Kaiserslautern, 26.–28. Juni 2019 (Vortrag).

Dietz, A.: Challenges for the Electrochemical/ Electroless Metallization of Additive Manufactured Polymer Parts, 236th Meeting der Electrochemical Society (ECS), Atlanta, GA, US, 13.–17. Oktober 2019 (Eingeladener Vortrag).

Dietz, A.; Moustafa, E.: Processes for the electrowinning of metals and oxygen from lunar regolith, 236th Meeting der Electrochemical Society (ECS), Atlanta, GA, US, 13.–17. Oktober 2019 (Vortrag).

Dietz, A.; Moustafa, E.: Electrowinning of metals and oxygen from lunar regolith, ESA: Space resources workshop, Luxemburg, Oktober 2019.

Dröder. K.; Hoffmeister, H.-W.; Tounsi, T.; Gäbler, J.; Paetsch, N.; Höfer, M.: Strukturierte CVD-Diamant-Mikroschleifstifte, F.O.M.-Konferenz 2019: Herausforderungen in Photonik und Medizintechnik, Berlin, 6. November 2019 (Poster).

Eichler, M: Atmosphärendruck-Plasmavorbehandlung von Optiken und Gläsern vor dem Kitten und Verkleben, 14. ThGOT Thementage Grenz- und Oberflächentechnik, Zeulenroda, 12.–13. März 2019 (Vortrag).

Gerdes, H.; Ortner, K.; Bandorf, R.; Schäfer, R.; Schütte, T.; Vergöhl, M.; Bräuer, G.: Microwave Plasma Assisted Chemical Vapor Deposition of SiO_x Films. 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April–2. Mai 2019 (Vortrag).

Gerdes, H.; Rieke, J.; Bandorf, R.; Schütte, T.; Vergöhl, M.; Bräuer, G.: Plasma Emission Monitor for controlling the ion to neutral ratio and stoichiometry of HIPIMS processes. International Conference on Sputter Technology / 10th International Conference on Fundamentals and Applications of HIPIMS, Braunschweig, 19. – 20. Juni 2019 (Poster).

Grube, M.; Hofer, M.; Hesselbach, J.; Michalowski, P.; Zellmer, S.; Kwade, A.: Syntheses of nickel-rich active materials and sulfidic solid electrolytes for ASSB cathodes, International Battery Production Conference IBPC 2019, Braunschweig, 4. – 6. November 2019 (Vortrag).

Grube, M.; Hesselbach, J.; Zellmer, S.; Kwade, A.: Syntheses for ASSB cathode materials, International Battery Production Conference IBPC 2019, Braunschweig, 4. – 6. November 2019 (Poster).

Herrmann, C.: Sustainability Through Data-Driven Computational Production and Life Cycle Engineering, 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April – 2. Mai 2019 (Keynote Lecture).

Herrmann, C.: Optimierung komplexer galvanischer Prozesse durch cyber-physische Systeme, ZVO-Oberflächentage 2019, Berlin, 11. – 13. September 2019 (Vortrag).

Herrmann, C.: Digitalization and computational engineering for plasma coaters, International Conference Power Electronics for Plasma Engineering PE², Zielonka / Warschau, Polen, 24. – 26. September 2019 (Vortrag).

Herrmann, C.: Nachhaltigkeit in der Oberflächentechnik durch Industrie 4.0 und Life Cycle Engineering, V2019 – Vakuum & Plasma, Dresden, 8. – 10. Oktober 2019 (Eröffnung inkl. Plenarvortrag).

Herrmann, C.: Sustainability in Surface Engineering by Industry 4.0 and Life Cycle Engineering, Smart Manufacturing Forum, Feng Chia University, Taichung, Taiwan, 28. November 2019 (Keynote-Vortrag).

Herrmann, C.: Digitalization and computational engineering for plasma coaters, Conference on Theoretical and Applied Mechanics (CTAM 2019), Taichung, Taiwan, 29. November 2019 (Keynote-Vortrag).

Herrmann, C.: Surface Engineering from coating processes to factories, Advanced Optical Coating Seminar, Feng Chia University, Taichung, Taiwan, 29. November 2019 (Vortrag).

Höfer, M.; Haase, E.: Moderner Pflanzenschutz durch Ozon, Innovate! Convention, Osnabrück, 16. – 17. Oktober 2019 (Eingeladener Vortrag).

Höfer, M.; Haase, E.; Beltz, H.M.; Schlenz, J.: Praxisgerechte, ressourcenschonende Reinigung von Pflanzen und Oberflächen durch Desinfektion mit elektrochemisch erzeugtem wassergelöstem Ozon, Innovate! Convention, Osnabrück, 16. – 17. Oktober 2019 (Poster).

Keunecke, M.: Prozesse zur Abscheidung reibungs- und verschleißmindernder DLC-Schichten, Seminar: PVD- und CVD-Beschichtungsverfahren für tribologische Systeme, Regensburg, 7. – 8. Oktober 2019 (Vortrag).

King, H.; Ortner, K.; Harig, T.; Höfer, M.; Sittinger, V.: Maximizing SiH_3 Radical Concentration During HWCVD Si:H Film Production by Means of Wire Temperature and Deposition Pressure Tuning, 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April – 2. Mai 2019 (Vortrag).

Kwade, A.; Zellmer, S.: Skalierbare Herstellungsprozesse für aktuelle und zukünftige Batterietechnologien, Hagener Symposium Pulvermetallurgie – Schlüsseltechnologie für innovative Systemlösungen, Hagen, 28. – 29. November 2019 (Vortrag).

Neubert, T.; Zeren, V.; Steinberg, C.; Thomas, M.; Cámara Torres, M.; Scopece, P.; Howitz, S.; Lachmann K.: Funktionale Beschichtungen auf 3D-gedruckten Polymerimplantatstrukturen, Wümek Kongress 2019, Würzburg, 8. – 9. Mai 2019 (Vortrag).

Neubert, T.; Lachmann, K.; Zeren, V.; Schlüter, F.; Scopece, P.; Patelli, A.; Thomas M.: Influence of the substrate temperature on the layer properties made by an atmospheric plasma jet using different precursors, 24th International Symposium on Plasma Chemistry, Neapel, Italien, 9. – 14. Juni 2019 (Vortrag).

Neubert, T.; Zeren, V.; Steinberg, C.; Thomas, M.; Schlüter, F.; Cámara Torres, M.; Scopece, P.; Howitz, S.; Lachmann K.: Funktionale Beschichtungen mittels Plasmajet auf 3D-gedruckten Polymerstrukturen, V2019 – Vakuum & Plasma, Dresden, 8. – 10. Oktober 2019 (Vortrag).

Neumann, F.; Borris, J.; Bunzel, F.: Wirtschaftliche Herstellung von Holzschaum mittels Photokatalyse – Recycelbare funktionale Leichtbauwerkstoffe auf Basis photo- und elektrochemisch aktiv modifizierter Holz-Schäume »Refuel-Phoams«, AG-Treffen »Plasma4Life«, Kompetenznetz Industrielle Plasma-Oberflächentechnik INPLAS e. V., Braunschweig, 12. März 2019 (Vortrag).

Neumann, F.: Revision of DIN 52980 Methylene Blue – Preliminary results and observations of German standardization project »DePhakto«; Photocatalysis Europe-PIAJ Joint Meeting, Deutsches Institut für Normung e. V., Berlin, 24. Oktober 2019 (Vortrag).

Ortner, K.: Deposition of thick piezoelectric films by Gas Flow Sputtering. International Symposium on Piezocomposite Applications ISPA 2019, Dresden, 9. – 11. Oktober 2019 (Vortrag).

Patelli, A.; Tamperi, F.; Marotta, E.; Zaniol, B.; Neubert, T.; Lachmann, K.; Scopece, P.; Mardegan, M.; Cattarruzza E.: A novel plasma jet with RF and HF coupled electrodes, 24th International Symposium on Plasma Chemistry, Neapel, Italien, 9. – 14. Juni 2019 (Vortrag).

Pflug, A.: Modellgestützte Herstellung optischer Filter auf gekrümmten Linsenflächen, Workshop »Sputtern für die Präzisionsoptik«, Fraunhofer IOF, Jena, 9. Mai 2019 (Vortrag).

Pflug, A.: Modelling of thin film deposition processes as a service, International Conference Power Electronics for Plasma Engineering PE^2, Zielonka / Warschau, Polen, 24. – 26. September 2019 (Vortrag).

Pflug, A.: Simulation assisted deposition of optical filters onto 3D substrates by magnetron-sputtering, 18th International Conference on Reactive Sputter Deposition RSD, Braunschweig, 5.–6. Dezember 2019 (Vortrag).

Schäfer, L.; Himmelsbach, T.; Schöniger, H.M.; Gäbler, J.: Strengthening groundwater management through an integrative approach, 2nd SADC Groundwater Conference, Johannesburg, South Africa, 4.–6. September 2019 (Vortrag).

Schäfer, L.: Fabrication of precision optical components and thin film sensors by integrated processes, Vacuum Coating Conference Shenzhen VCCS, 22. November 2019 (Eingeladener Vortrag).

Schäfer, L.; Sittinger, V.; Höfer, M.; Justianto, M.; King, H.; Harig, T.; Thiem, H.: Applications of Silicon-based Coatings Deposited by Hot-Wire CVD, Advanced Optical Coating Seminar, Feng Chia University, Taichung, Taiwan, 29. November 2019 (Vortrag).

Schiffmann, K.: Analyse- und Prüfverfahren von Schichten für tribologische Anwendungen, Seminar: PVD- und CVD-Beschichtungsverfahren für tribologische Systeme, Regensburg, 7.–8. Oktober 2019 (Vortrag).

Schott, A.: Multisensorische Dünnschichtsysteme, Industriearbeitskreis Werkzeugbeschichtungen und Schneidstoffe, Braunschweig, 7. November 2019 (Vortrag).

Schütte, T.; Neiß, P.; Rieke, J.; Gerdes, H.; Bandorf, R.; Vergöhl, M.; Bräuer, G.: How to run a reliable reactive HIPIMS process over a target lifetime. 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April–2. Mai 2019 (Vortrag).

Schütte, T.; Neiß, P.; Rieke, J.; Gerdes, H.; Bandorf, R.; Bräuer, G.: Combined control of ionization and stoichiometry in reactive highly ionized processes for production lines. International Conference on Sputter Technology / 10th International Conference on Fundamentals and Applications of HIPIMS, Braunschweig, 19.–20. Juni 2019 (Vortrag).

Sittinger, V.: Route to optimized aluminum-doped zinc oxide films from metallic rotatable sputter targets on large area for thin film photovoltaic modules, 3. International Symposium on Coatings on Glass and Plastics, Tokyo, Japan, 4.–5. April 2019 (Vortrag).

Sittinger, V.; Schäfer L.; Gäbler, J.; Höfer, M.; Bräuer, G.; Bond, R.J.; Matthée, T.; Brackemeyer, D.; Wilsenach, J.; Woods, M.: 62nd Annual Technical Conference of the Society of Vacuum Coaters SVC, Long Beach, CA, US, 27. April–2. Mai 2019 (Vortrag).

Ulrich, S.: Entwicklung elektrochromer Materialien, V2019 – Vakuum & Plasma, Dresden, 8.–10. Oktober 2019 (Vortrag).

Thomas, M.; Lachmann, K.; Eichler, M.; Mann, A.; Neubert, T.; Klages, C.-P.; Herrmann, C.; Bräuer, G.: Plasma 4.0 – Selective surface functionalization by atmospheric pressure plasmas, Asian European Conference on Plasma Surface Engineering (AEPSE), Maison Glad Hotel, Jeju City, Korea, 1.–5. September 2019 (Invited Plenary Talk).

Thomas, M.; Mennenga, M.; Thiede, S.: Nachhaltige Produkte und Prozesse für New Energy Vehicles, Fachtagung Leichtigkeit PUR, OHLF, Wolfsburg, 19. September 2019 (Vortrag).

Vergöhl, M.: Deposition of Demanding Optical Coatings on Curved Substrates, Optical Interference Coatings Conference OIC, New Mexico, USA, 2.–7. Juni 2019 (Poster).

Weber, M.: Auswahl und Vorbehandlung der Werkstoffe für die Beschichtung, Seminar: PVD- und CVD-Beschichtungsverfahren für tribologische Systeme, Regensburg, 7.–8. Oktober 2019 (Vortrag).

Zellmer, S.: Einsatz prozessbegleitender Analytik entlang der gesamten Wertschöpfungskette für die Batteriezellproduktion, 2. PPA-Netzwerktreffen 2019, Göttingen, 29. August 2019 (Vortrag).

Dissertations

Abraham, T.: Entwicklung von Kohlenwasserstoffschichten für die schmiermittelfreie Kaltumformung von Aluminiumblechen durch Tiefziehen. Dissertation, Technische Universität Braunschweig, 2019.

Master's theses

Arafat, R.: Untersuchung des Einsatzpotentials von supercritical CO_2 als Kühlschmierstoffalternative für die Schleifbearbeitung, Technische Universität Braunschweig, Juni 2019.

Awate, A. S.: Experimental and theoretical investigation of machining processes, Technische Universität Braunschweig, Juni 2019.

Berkan, P.: Erstellung eines Montagekonzepts für die automatisierte Schließösenmontage mit Fokus auf die intelligente Datenvernetzung, Technische Universität Braunschweig, Oktober 2019.

Blömeke, S.: Entwicklung eines Kennzahlensystems zur Bewertung sowie Modellierung und Simulation von Closed-loop Production Systems, Technische Universität Braunschweig, April 2019.

Bommes, L.: Shopfloor Monitor: Multi-Camera-Based Detection and Tracking System for a large Manufacturing Environment, Technische Universität Braunschweig, März 2019.

Brand, C.: Ökobilanzierung einer LVP-Sortieranlage, Technische Universität Braunschweig, Oktober 2019.

Britze, C.: Entwicklung eines schmalen IR-Bandpassfilters auf einer asphärischen Linse, Technische Universität Braunschweig, August 2019.

Csuti, J.: Entwicklung und Ausgestaltung eines Predictive Maintenance Service-Delivery Konzeptes für das BASF Reliability Center – Development and design of a predictive maintenance service-delivery concept for the BASF Reliability Center, Technische Universität Braunschweig, Februar 2019.

Czarski, M.: Development of an indoor mixed reality visualization concept for manufacturing shop floors with implementation in learning factories, Technische Universität Braunschweig, Juli 2019.

Dierkes, J.: Bewertung von Methoden des energieeffizienten Produktionsmanagements zur Anwendung in energieflexiblen Produktionen, Technische Universität Braunschweig, Dezember 2019.

Dilger, N.: Energy and resource flow modelling of a PAN-based carbon fibre white and black manufacturing line, Technische Universität Braunschweig, Januar 2019.

Feist, L.: Ökobilanzierung der PET-Wertschöpfungskette mit Fokus auf PET-Produktion, Technische Universität Braunschweig, Oktober 2019.

Franke, J. F.: Entwicklung und exemplarische Anwendung einer Methodik zur Beschreibung, Modellierung und Bewertung autonomer Mobilität als System der Systeme, Technische Universität Braunschweig, März 2019.

Ghazi, M.: Entwicklung eines Chargenführungskonzeptes am Beispiel der Batteriezellproduktion der Battery LabFactory Braunschweig, Technische Universität Braunschweig, August 2019.

Gödecke, D.: Entwicklung eines Konzeptes zur Potentialabschätzung der Wiederverwendbarkeit von Betriebsmitteln im Automobilbau am Beispiel einer Karosseriebauanlage, Technische Universität Braunschweig, März 2019.

Görtz, J.: Integration von GIS Technologien in LCA für die Analyse von Umweltauswirkungen der Energieproduktion, Technische Universität Braunschweig, Januar 2019.

Haller, F.: Grundlegende Untersuchungen zur Plasmanitrierung von Aluminium bei Atmosphärendruck, Technische Universität Braunschweig, April 2019.

Hassan, H.: Simulation of Scale-Effects in the Production of Lithium-ion Traction Batteries for Electric Vehicles, Technische Universität Braunschweig, Oktober 2019.

Helmke, M.: Analyse und Bewertung von Produktionstechnologien und -systemen für urbane Fabriken, Technische Universität Braunschweig, Juli 2019.

Hohmann, L.: Umsetzung eines Steuerungskonzeptes zur individualisierten Arzneiabfüllung im Rahmen einer wandlungsfähigen Produktionszelle, Technische Universität Braunschweig, September 2019.

Hou, L.: Anwendung von Data-Mining-Methoden zum Energiebenchmarking von Fabriken, Technische Universität Braunschweig, Dezember 2019.

Huang, Y.: Auswertung von hochfrequenten Daten in der Produktionstechnik, Technische Universität Braunschweig, November 2019.

Huang, Y.: Simulation based data analytics in industry, Technische Universität Braunschweig, Oktober 2019.

Ji, H.: Identifikation und Bewertung von Technologien zur Erfassung von Daten im Batterielebenszyklus, Technische Universität Braunschweig, Oktober 2019.

Knop, H.: Modellierung und Simulation von Produktions- und Recyclingprozessen im Kontext von Closed-loop Production Systems, Technische Universität Braunschweig, März 2019.

Kont, M.: Ökologische Bewertung von Substitutionsszenarien im automobilen Leichtbau, Technische Universität Braunschweig, Juni 2019.

Kröger, F.: Systematische Identifikation von Energiesparpotentialen in Industrieunternehmen, Technische Universität Braunschweig, August 2019.

Langner, J.: Konzeption und Validierung eines datenbasierten Prognosetools für die Planung von Wartungs- und Instandhaltungsprozessen im Bereich der Luftfahrt, Technische Universität Braunschweig, Mai 2019.

Li, S.: Entwicklung und Evaluation eines Mixed Reality Produktionsprozess für skalierte Lernfabriken, Technische Universität Braunschweig, März 2019.

Lips, J.: Life Cycle Assessment von PET-Produktion und relevanten Vorketten mit Fokus auf Analyse des Einflusses von Datenunsicherheiten, Technische Universität Braunschweig, Dezember 2019.

Maaßen, F.: Methoden- und Kriterienentwicklung für standardisierte LCAs von Bahnautomatisierungsprodukten, Technische Universität Braunschweig, Januar 2019.

Matthäi, J.: Entwicklung einer generischen Simulationsmethodik für cyber-physische Systeme auf Fabrikebene, Technische Universität Braunschweig, November 2019.

Mohwinkel, D.: Randschichtbehandlung von Hochtemperaturlegierungen für den Werkzeugbau und deren tribologische Bewertung Technische Universität Braunschweig, 2019.

Munoz Amador, O. A.: Identifikation und modellbasierte Bewertung industrieller Symbiose von urbaner Gemüseproduktion, Technische Universität Braunschweig, Oktober 2019.

Oberländer, M.: Konzeption und Validierung eines Datenerfassungskonzeptes für die Anwendung im Bereich „Predictive Maintenance“, Technische Universität Braunschweig, April 2019.

Ogaza, A.: Industrielle Verfahrensübersicht PECVD, Technische Universität Braunschweig, Dezember 2019.

Paehr, A.: Untersuchung und Bewertung potentieller Kreislaufstrategien für Verschleißteile in der Flugzeugfahrwerksinstandhaltung, Technische Universität Braunschweig, August 2019.

Pan, X.: Hochfrequente Daten Erfassung für die Produktionstechnik, Technische Universität Braunschweig, November 2019.

Pape, H.: Prädiktion von CFD-Simulationen mittels Machine Learning Methoden, Technische Universität Braunschweig, Oktober 2019.

Popov, D.: Untersuchungen zur Plasmabehandlung von porösen Polymeren, Technische Universität Braunschweig, August 2019.

Pydde, K.: Entwicklung und Integration eines Mixed Reality Interfaces für/in ein Industrie 4.0 Test-bed, Technische Universität Braunschweig, Juli 2019.

Raymann, K.: Enabling Tracking and Tracing of Lithium-Ion Battery Electrodes in Continuous Production Processes, Technische Universität Braunschweig, November 2019.

Rösler, J.: Laser-Oberflächenbehandlungen für Raumfahrtanwendungen, Technische Universität Braunschweig, August 2019.

Rudolf, S. M.: Entwicklung eines Analyse- und Bewertungsvorgehens für das Potential urbaner Fabriken für die Ausführung von urbanen Funktionen im städtischen Raum als „Urban Services“, Technische Universität Braunschweig, März 2019.

Scheck, N.: Data Mining Methoden für das Wissensmanagement in der Forschung zur Batteriezellproduktion, Technische Universität Braunschweig, Februar 2019.

Schmidt, S.: Bewertung der Energie- und Materialeffizienz in der Produktion von Karosseriebauteilen, Technische Universität Braunschweig, September 2019.

Schneider, E. U.: Erarbeitung eines Konzepts zum ganzheitlichen Recycling von Traktionsbatterien, Technische Universität Braunschweig, Mai 2019.

Schott, A.: Untersuchungen zum Einfluss der Depositionsparameter beim Magnetronsputtern auf Morphologie, mechanische Eigenschaften und Benetzung von Schichten im System Cr-N-O, Technische Universität Braunschweig, April 2019.

Sommer, D.: Assessment of implementations for 5G communication standard in industrial Sector by means of a use case and exemplary implementation at AMTC Testbed of Tongji University, China, Technische Universität Braunschweig, August 2019.

Sommer, P.: Konzeptentwicklung einer integrierten Kommunikationstechnologie in Feststoffarzneiformen zum Track & Tracing in Produktionsprozessen zur kundenindividuellen Arzneimittelherstellung, Technische Universität Braunschweig, August 2019.

Stascheit, C. W.: Assessing the environmental impact of photovoltaic systems, Technische Universität Braunschweig, Oktober 2019.

Stendel, A.: Literaturbasierte Ermittlung des realen Energiebedarfs von batterieelektrisch betriebenen Fahrzeugen, Technische Universität Braunschweig, März 2019.

Taoying, S.: Data based assessment of the viability and environmental impact of using plug-in hybrid vehicles in police fleets, Technische Universität Braunschweig, Februar 2019.

Timmermann, I.: Entwicklung und Konzeption einer Methodik zur Prozess- und Qualitätsoptimierung in der Montage von Windenergieanlagen unter Anwendung einer digitalen Datenerfassung, Technische Universität Braunschweig, Februar 2019.

Trilling, J.: Induktives Einschmelzen flammgespritzter Schichten, Technische Universität Braunschweig, Mai 2019.

Trümper, T.: Simulative Optimierung des Energiebedarfs in der Baterieproduktion, Technische Universität Braunschweig, September 2019.

Tüting, J.: Praktische Versuche zum und theoretische Untersuchung des Remanufacturings von LED Schweinwerfern im Kontext Recycling 4.0, Technische Universität Braunschweig, März 2019.

Ventura Silva, G.: Development and conception of a life cycle oriented data acquistion and data storage concept on the example of production, Technische Universität Braunschweig, Dezember 2019.

Wang, X.: Advanced Energy Reporting by utilizing a Machine Learning Approach, Technische Universität Braunschweig, Juni 2019.

Weber-Renz, A.: Ökologische Bewertung und Vergleich eines Monopräparates mit einem Kombipräparat von der Wirkstoffherstellung bis zu fertigen Tablette, Technische Universität Braunschweig, Februar 2019.

Weerts, A.: Life Cycle Assessment (LCA) of Autonomous Electric Vehicles, Technische Universität Braunschweig, August 2019.

Weiß, J. T.: Entwicklung einer Methode zur kundenfunktionsorientierten Bauteilkostenberechnung zukünftiger Elektrofahrzeugkonzepte, Technische Universität Braunschweig, Oktober 2019.

Willenbrock, B.: Ökologische Bewertung neuartiger symbiotischer Nahrungsmittel Produktionssysteme, Technische Universität Braunschweig, Mai 2019.

Zhao, Z.: Sensitivitätsanalyse in der Ökobilanz der Wertschöpfungskette von Kobalt und Nickel für Batterieanwendungen, Technische Universität Braunschweig, Januar 2019.

Bachelor's theses

Amtz, J.: Bewertung nitrierter Bauteile, Technische Universität Braunschweig, Bachelorarbeit, März 2019.

Bertram, P.: Grundlagenuntersuchungen zum Verhalten nitrierter Warmarbeitsstähle bei Thermowechselbeanspruchung, Technische Universität Braunschweig, Bachelorarbeit, November 2019.

Hell, K: Atmosphärendruck-Plasmavorbehandlung lackierter Oberflächen zur klebfreien Maskierung vor der Zweifarbenlackierung, Technische Universität Braunschweig, Bachelorarbeit, Januar 2019.

Köhl, C.: Erarbeitung eines Kalibrierversuchs für einen Tribologieprüfstand, Technische Universität Braunschweig, Bachelorarbeit, Juli 2019.

Lai. Z.: Entwicklung eines Messplatzes zur Charakterisierung der Dehnungsempfindlichkeit von Dünnschichten auf Polymerfolien, Technische Universität Braunschweig, Bachelorarbeit, März 2019.

Ritzka, J.: Auswirkung des Plasmanitrierens auf das Korrosionsverhalten austentischer Stähle, Technische Universität Braunschweig, Bachelorarbeit, Juni 2019.

Patent applications

Fischer, F.; Kunze, C.; Bäthge, S.; Giesert F.; Brand, J.: Holzfuniere (behandelt/unbehandelt) mit einer dünnen elektrischleitfähigen Funktionsschicht.

Mainusch, N.; Scholz, D.; Viöl W.; Kappertz, O.; Tieleborger T.: Gerät und Verfahren De-Agglomeration und Beschichtung von Trockenstoffen wie Fasern und Pulvern.

PICTURE INDEX

55 Fig 3. Illustration: Falko Oldenburg, Fraunhofer IST
56 Photo: Falko Oldenburg, Fraunhofer IST
58 Fig 1. Bilal Temel, Institut für Partikeltechnik iPAT, TU Braunschweig; Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover
58 Fig 2. Institut für Chemische und Thermische Verfahrenstechnik ICTV, TU Braunschweig
60 Fig 2. Fraunhofer IST
61 Fig 1. Fraunhofer IST
62 Photo: Falko Oldenburg, Fraunhofer IST
64 Fig 1. Fraunhofer IST
64 Fig 2. Fraunhofer IST
65 Fig 3. Fraunhofer IST
66 Fig 1. Fraunhofer IST
66 Fig 2. Fraunhofer IST
67 Fig 3. Photo: André Kaiser, Fraunhofer IST
68 Fig 1. Fraunhofer IST
69 Fig 2. Fraunhofer IST
70 Photo: Falko Oldenburg, Fraunhofer IST
72 Fig 1. Photo: Virtual Consulting Engineers
72 Fig 2. Photo: Virtual Consulting Engineers
73 Fig 3. Photo: Lothar Schäfer, Fraunhofer IST
74 Fig 1. Photo: Hannes Meyer, Fraunhofer IST
76 Photo: Falko Oldenburg, Fraunhofer IST
78 Fig 1. Photo: Falko Oldenburg, Fraunhofer IST
78 Fig 2. Photo: Krees Nagel, Fraunhofer IST
79 Fig 3. Photo: Falko Oldenburg, Fraunhofer IST
80 Fig 1. Photo: Rainer Meier, BFF Wittmar
80 Fig 2. Photo: Falko Oldenburg, Fraunhofer IST
81 Fig 3. Photo: Falko Oldenburg, Fraunhofer IST
82 Fig 1. Illustration Falko Oldenburg, Fraunhofer IST
82 Fig 2. Fraunhofer IST
83 Fig 3. Illustration Falko Oldenburg, Fraunhofer IST
84 Photo: Falko Oldenburg, Fraunhofer IST
86 Fig 1. Photo: Sandra Yoshizawa, Fraunhofer IST
87 Fig 2. Photo: Holger Gerdes, Fraunhofer IST
88 Fig 1. Photo: Sandra Yoshizawa, Fraunhofer IST
88 Fig 2. Photo: Fraunhofer IST
89 Fig 3. Photo: Falko Oldenburg, Fraunhofer IST
90 Fig 1. Photo: Falko Oldenburg, Fraunhofer IST
90 Fig 2. Photo: Julia Hardt, Fraunhofer IST
91 Fig 3. Photo: Fraunhofer IST
92 Fig 1. Photo: Ulrike Balhorn, IOT, TU-Braunschweig
92 Fig 2. Photo: Falko Oldenburg, Fraunhofer IST
93 Fig 3. Photo: Ilka Blumentritt, Fraunhofer IST
94 Photo: Ulrike Balhorn, IOT, TU-Braunschweig
95 Fig 1. Photo: Ulrike Balhorn, Fraunhofer IST
96 Photo: Falko Oldenburg, Fraunhofer IST
106 Fig 1. Photo: Falko Oldenburg, Fraunhofer IST
106 Fig 2. Photo: Falko Oldenburg, Fraunhofer IST
107 Fig 3. Photo: Falko Oldenburg, Fraunhofer IST
109 Fig 2. Photo: Ilka Blumentritt, INPLAS e. V.

EDITORIAL NOTES

Fraunhofer Institute for Surface Engineering
and Thin Films IST

Director of the Institute
Prof. Dr. Günter Bräuer
Prof. Dr.-Ing. Christoph Herrmann

Deputy Director of the Institute
Dr. Lothar Schäfer

Bienroder Weg 54 E
38108 Braunschweig, Germany
Phone +49 531 2155-0
Fax +49 531 2155-900
info@ist.fraunhofer.de
www.ist.fraunhofer.de

Editorial and coordination
Dr. Simone Kondruweit
Daniela Kleinschmidt, M. A.

Layout
Dipl.-Des. Falko Oldenburg

Print
ROCO Druck GmbH
https://www.rocodruck.de