Fraunhofer IST

Fraunhofer Institute for Surface Engineering and Thin Films IST

Annual Report 2022

Cover

Data acquisition and simulation for optimized processes and energy consumption: In addition to the simulation of room-air flows, the Fraunhofer IST is also addressing the data acquisition and digitization of process flows in hospitals.

Fraunhofer IST Annual Report

2022

"What will the energy supply of tomorrow look like? How do we configure sustainable production? What can we contribute towards optimal medical care? How can digitalization help to increase yields in agriculture and protect the environment? These and many other questions motivate us at the Fraunhofer IST to do our very best each and every day."

Prof. Dr.-Ing. Christoph Herrmann / Institute Director

Foreword of the Institute management

Ladies and Gentlemen,

For the Fraunhofer IST as well as for the Fraunhofer-Gesellschaft as a whole, an integral element of our self-image is to always act in close solidarity with local university partners and to practice cooperation with industry and further partners.

One outstanding example of this solidarity and cooperation is the joint research into next-generation mobile and stationary energy storage systems. At the Fraunhofer Center for Energy Storage and Systems ZESS, we are working on the development of materials and processes as well as the planning and design of production processes and the layout of battery factories – thereby taking technological, economic and ecological aspects into account.

Two further outstanding cooperations are the Wasserstoff Campus Salzgitter and the Open Hybrid LabFactory research campus in Wolfsburg. The aim here is to rapidly implement the application of innovations for a circular economy in the automotive industry – on the basis of an excellent cross-organizational research infrastructure. This also encompasses customized training concepts.

At the Fraunhofer IST, we advocate not only innovative products and processes, but also a modern working environment. In order to do justice to the needs of our employees and to promote a cooperative, creative atmosphere, we are working on the adaptation and implementation of tailored new-work concepts. In the certification process of the Arbeitgeberverband Region Braunschweig e.V. (Braunschweig regional employers' association, AGV), we achieved top marks and are now entitled to bear the "Zukunftgeber" employer seal. Furthermore, we have been distinguished by the Braunschweig Chamber of Industry and Commerce for our commitment as a training company and are, of course, particularly proud of the achievements of our trainees, who were this year once again among the best.

A further highlight was the opening of the "patient room of the future" in collaboration with the TU Braunschweig and the Städtisches Klinikum Braunschweig, which is to be used as an application-oriented research and study laboratory and for clinical further training. In addition to practicable technical construction sample solutions, innovative smart materials and surfaces as well as future-proof equipment elements and products for infection prevention and cleaning are to be developed and tested here.

Within the framework of the Fokusreise Strukturwandel (focus journey on structural change), we were able to welcome Fraunhofer President Professor Reimund Neugebauer to the former Helmstedter Revier open-cast coal mine. In collaboration with the Fraunhofer IKTS, the Fraunhofer IST plans to network supra-regional initiatives and regional partners at the Helmstedt location and to pool competences, including those of the TU Braunschweig, the Julius Kühn Institute and the Thünen Institute. One goal is to work together with stakeholders on the development and testing of technological solutions to the challenges faced by the agricultural sector.

We look forward to this and to many further exciting joint projects and collaborations with you. We would like to thank you, our partners from research and development, our clients from industry, our sponsors, colleagues and friends, for the trusting cooperation.

At this point, I would like to express my special thanks to the employees of the institute, whose performance, commitment, trust and support enable the Fraunhofer IST to serve as an impetus for innovative developments and play a part in shaping our future.

I sincerely hope that you will enjoy reading this Annual Report.

Prof. Dr.-Ing. Christoph Herrmann

Content

Content

Our Board of Trustees

Interface between research and practice

The members of our Board of Trustees advise and support us in questions of professional orientation as well as structural changes and provide our institute with important impulses. After two virtual meetings, the 2022 meeting of the Board of Trustees was finally held in person again. Our top-class Board of Trustees is comprised of representatives from science, business and public life:

Chairman

Dr. Philipp Lichtenauer
Plasmawerk Hamburg GmbH

Prof. Dr. Peter Awakowicz
Ruhr-Universität Bochum

Dr. med. Thomas Bartkiewicz
Städtisches Klinikum Braunschweig gGmbH

Frank Benner
B+T Technologies GmbH

Claudia Martina Buhl
VDI/VDE Innovation + Technik GmbH

Prof. Dr. Tim Hosenfeldt
Schaeffler Technologies AG & Co. KG

Dr. Sebastian Huster
Niedersächsisches Ministerium für Wissenschaft und Kultur

Prof. Dr. Angela Ittel
Technische Universität Braunschweig

Hon.-Prof. Dr.-Ing. Michael Juhnke
F. Hoffmann-La Roche AG

Prof. Dr. Simone Kauffeld
Technische Universität Braunschweig

Prof. Dr.-Ing. Frank Kleine-Jäger
BASF SE

Cordula Miosga
Arbeitgeberverband Region Braunschweig e.V.

Dr.-Ing. Stefan Rinck
Singulus Technologies AG

Dr. Joachim Schulz
Verband der Metall- und Elektroindustrie
Baden-Württemberg e. V. (Südwestmetall)

Michael Stomberg
Bauer AG

Dr. Jutta Trube
Verband Deutscher Maschinen- und Anlagenbau e.V.

Dr. Ernst-Rudolf Weidlich
GRT GmbH & Co. KG

Guest:
Dr. Kai U. Ziegler
Eagle Burgmann Germany GmbH & Co. KG

Excellent Collaboration

An Interview with Frank Benner, CEO of the B+T Group of companies

1

Personal details

After completing his training as a nurse, Frank Benner worked for several years in intensive-care medicine and finally in the cardiac-surgery intensive-care unit at the Rhön-Klinikum. In 1989, he transferred to surface technology. After taking his final apprenticeship exam ahead of schedule, he subsequently passed his master craftsman's exam as an electroplater and metal grinder two years later.

He then worked as managing director and responsible person for surfaces and coating systems worldwide for a corporation in the automotive supply industry. In 2006, he moved to Ruhl & Co GmbH in Wetzlar, now B+T Oberflächentechnik, where he became managing partner. This was followed by the founding of the B+T group of companies with the integration of B+T Oberflächentechnik, which received the "Wachstumschampion 2017" (growth champion) award and is one of the 500 most successful companies in Germany.

What are the current challenges for your industry and what contribution is provided by the Fraunhofer IST in this context?

"In surface technology, the digital transformation is still in full swing. Digitally mapping the analog flows of goods, materials and information is a challenge which we successfully address on a daily basis. This involves, firstly, the monitoring of the utilized resources, from raw materials, operating equipment and tools right through to the use of energy, and, secondly, the tracing of the CO_2 footprint. B+T is definitely on the right track in the sustainable orientation of its production technology, but there is still work to be done in order to determine the CO_2 footprint of the individual products. The Fraunhofer IST and its staff are a valuable partner to us in this area, and also in diverse research projects. We very much appreciate the uncomplicated way in which you provide us with advice and support."

You have been working in collaboration with the Fraunhofer IST since 2008. What special project stands out and distinguishes your collaboration with the IST?

"I have particularly fond memories of the first joint research project. This involved the incorporation of corrosion-active nano-containers in a chemo-mechanical coating process for high-strength components in order to optimize the desired product requirements with regard to corrosion protection, ductility and tribological properties.

2

Coating plant at the Rechtenbach location.

The exchange on an equal footing among experts, combined with the approach to the new subject matter, was tremendous fun with the Fraunhofer IST. The collaboration is always associated with a considerable gain in knowledge and results which can be usefully implemented in practice."

What plans do you have – also with regard to the Fraunhofer IST – for the future?

"Currently, an application for the NachDiGal research project (Nachhaltige Digitale Geschäftsmodelle für die Galvanotechnik: Sustainable digital business models for electroplating) is in the review and approval phase. Collaboration with a large number of companies and institutions is hereby planned, across all processes along the electroplating supply chain, from production through to disposal, with the involvement of electrolyte manufacturers and also authorities, in this case the Regierungspräsidium Gießen (Giessen Regional Council). The aim is the development of digital services for sustainable process management, increased efficiency and transparency, simplification of processes and automated reporting.

Furthermore, in the future we will strive towards the utilization of alternative energy sources, in particular hydrogen - we see and appreciate the head start in knowledge that the Fraunhofer IST has in this technology of the future."

Family business in third generation. From left to right: Sarah Benner, Willi Perschbacher, Annalina Benner and Frank Benner.

The B+T Group of Companies

B+T: "Benner and Daughters". In third generation, the shareholders Annalina and Sarah Benner represent the future orientation of the company. The company founder Frank Benner, after whom the company is named, set the course for this.

With its roots in surface technology, the company continues to focus on the areas of hardening, surface coating and logistics.

Founded at the beginning of 2019, B+T K-Alpha GmbH specializes in the development and marketing of X-ray analytical measurement methods in coating technology and their integration for utilization in electroplating 4.1.

With its innovative individual solutions, the newest division B+T ID Solutions GmbH covers the extensive area of process optimization in production and logistics. With RFID devices developed and produced in Germany and software solutions from the B+T IT department, customers from industry, food production, trade, crafts, the public sector and many other fields can be addressed.

Further information: https://bt-unternehmensgruppe.de

The B+T headquarters in Rechtenbach with central administration offices and adjoining factory.

Institute profile

As an innovative and internationally recognized partner for research and development, the Fraunhofer Institute for Surface Engineering and Thin Films IST develops future-oriented products – including the associated competitive and scalable production systems.

Our research encompasses plant engineering, entire process chains of process engineering, process technology and manufacturing technology all the way through to the consideration of entire factories. Taking the requirements of sustainability as a starting point, we maintain an overview of the entire product life cycle – from the material, through the process of creating the component and product, and on to recycling.

Tailor-made and sustainable: Our sector-based solutions

In interdisciplinary teams and based on our technology and competence fields, we offer our customers from industry and research customized solutions that fulfill the requirements for sustainability for various sectors, e. g. plant and mechanical engineering, tools, vehicle construction, aerospace, energy, optics, medical and pharmaceutical process engineering, environmental technology, chemistry, and the digital economy.

Drawing on a broad spectrum of expertise, technologies, processes and coating materials, we design the optimum process chain for the respective task, right through to the digital design of the entire factory.

The core competencies of the Fraunhofer IST are:

- Energy storage systems with focus on battery cell production and hydrogen technology
- Micro and sensor technology / Industry 4.0
- Tribological systems
- Precision optical coatings
- Multifunctional surfaces for medical technology and pharmaceutical production
- Flexible production systems
- Cyber-physical systems and Computational Surface Engineering & Science

We apply our expertise in a diverse range of technologies for the coating, treatment and structuring of surfaces and the design of the associated production systems. These include:

- 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
- Atomic layer deposition (ALD)
- Chemical, mechanical and thermal surface treatment

Furthermore, the Fraunhofer IST is very well equipped as regards surface analytics and has accrued many years of expertise in quality assurance. Added to this is extensive experience in the modeling and simulation of both product properties and the associated processes as well as production and factory systems. For the systematic consideration of sustainability requirements, the Fraunhofer IST offers extensive expertise in quantitative sustainability assessment (life-cycle costing, life-cycle assessment) and system design (life-cycle engineering).

The range of services offered by the Fraunhofer IST is complemented in particular by the other member institutes and facilities of the Fraunhofer Group for Production. The Group pools the expertise of the Fraunhofer-Gesellschaft for the "production of the future" and elaborates innovative system solutions along the entire value chain.

Within the framework of direct contract research, the Fraunhofer IST offers its customers not only the licensing of software, patents and expertise but also consulting and innovation management, customized further-training programs, and services in the fields of process development and equipment and plant engineering. Alongside direct contract research, we work together with partners from industry and science in publicly funded projects. In addition to application-oriented research, the staff of the Fraunhofer IST also carry out the associated fundamental scientific work in cooperation with universities and non-university research institutes.

At its main location in Braunschweig, the institute has 4000 square metersof office and laboratory space as well as additional 1000 square meters for energy storage research at the Bevenroder Straße site.

At the Fraunhofer Center ZESS, we are developing sustainable next-generation energy storage systems and are advancing them to market maturity. We thereby consider the entire life cycle, from raw material through to recycling, from the point of view of technical, economic and ecological aspects. A new research building is planned for the work at the Research Airport Campus in Braunschweig. During the transition phase, employees will have access to around 250 square meters of laboratory space in the Automotive Research Centre Niedersachsen NFF and 400 square meters of office space in the Lilienthalhaus at Braunschweig Research Airport.

At the Wolfsburg location, the Fraunhofer IST is a partner in the Fraunhofer Center Circular Economy for Mobility CCEM. The center is part of the Open Hybrid LabFactory (OHLF), a research campus and a platform of public-private partnership for innovation. The focus there is on the urgent question as to how industrial vehicle production can become sustainable and be configured in accordance with a circular economy.

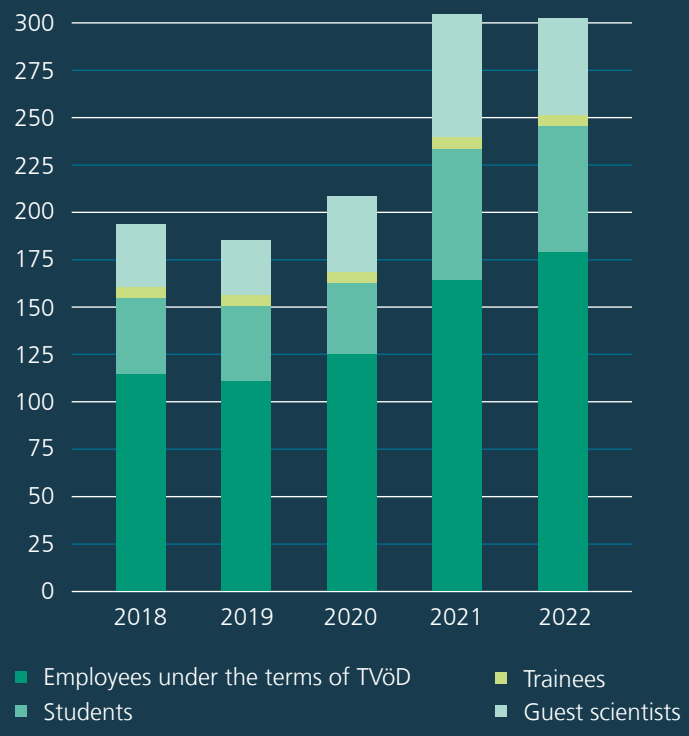
The industrial utilization of hydrogen is highly relevant with regard to both the energy revolution and a resilient energy supply. The industrial utilization of hydrogen is highly relevant with regard to both the energy revolution and a resilient energy supply. At the Salzgitter location and the Wasserstoff Campus established there, the Fraunhofer IST is working together with regional companies on technologies and concepts for the production and utilization of green hydrogen on an area of just under 2500 square meters.

In addition, the building of the application center of the Fraunhofer IST in Göttingen in cooperation with the local university provides 1500 square meters of office and laboratory area. One focus here is cold plasma spraying. At the Dortmund location, the Fraunhofer IST has 1100 square meters of technical center and office space in which work is carried out on coatings and diffusion treatments for the development of wear-resistant and temperature-resistant surfaces.

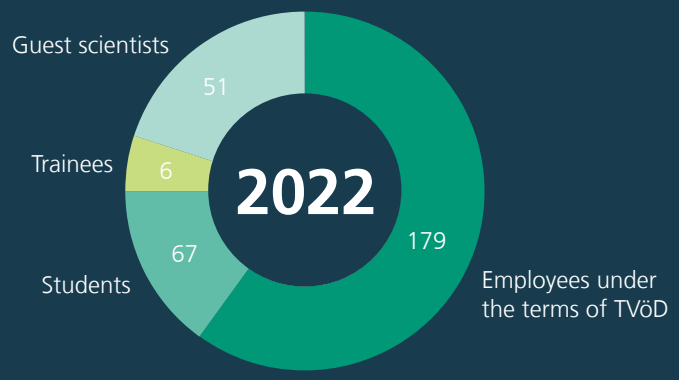
For the Fraunhofer IST as well as for the Fraunhofer institutes as a whole, it is a matter of principle to always interact closely with the local universities. For the institute, with its headquarters in Braunschweig and regional locations in Wolfsburg and Salzgitter, the Technische Universität Braunschweig is, correspondingly, a central cooperation partner. The TU institutes directly associated with the Fraunhofer IST include: Institute of Machine Tools and Production Technology (IWF), Institute for Surface Technology (IOT), and the Institute for Particle Technology (iPAT).

The institute in figures

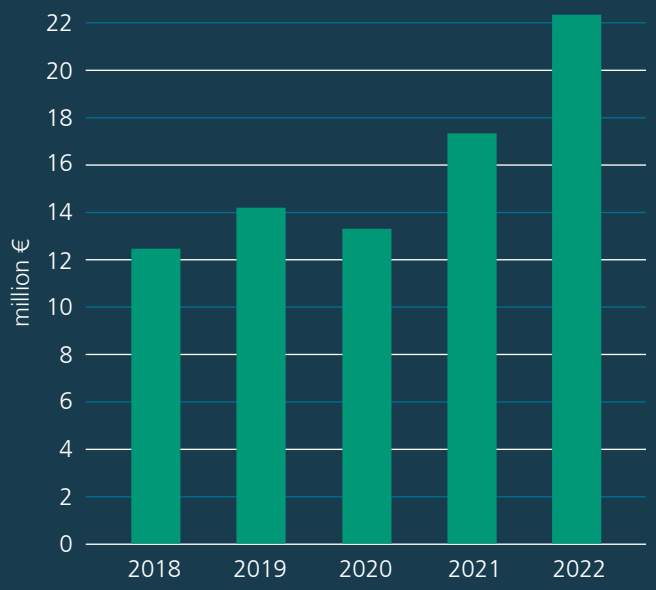
Personnel development



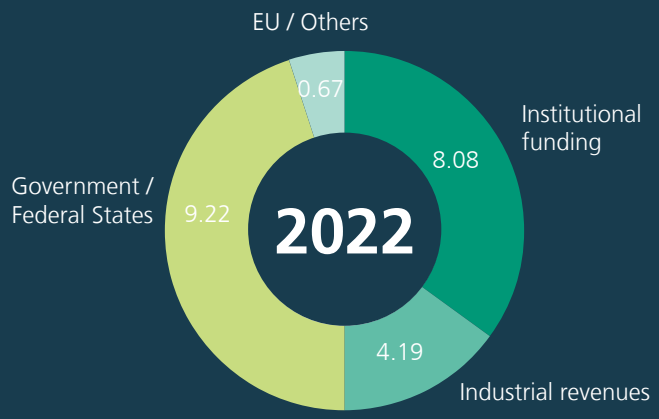
303
employees



Overall budget



€ 22.16 million
overall budget



8 professorships

8 nationalities

>15 disciplines

43 conference contributions

7 locations

*Employees under the terms of TVöD

4 vocational professions

69 student assistants

6 trainees

11 trade fairs and exhibitions

Professorships

The Fraunhofer IST cooperates with numerous institutes and centers of the TU Braunschweig. Thanks to the close ties with the university, we can build our project work on the latest results from university research. The Fraunhofer IST maintains connections with the Technische Universität Braunschweig in the form of seven associated professorships. Since 2012, the institute has also been cooperating with the HAWK University of Applied Sciences and Arts Hildesheim / Holzminden / Göttingen within the framework of the Application Center in Göttingen.

Technische Universität Braunschweig

Institute of Machine Tools and Production Technology (IWF)

Prof. Dr.-Ing. Christoph Herrmann
Research foci:

- Sustainable manufacturing
- Life cycle engineering
- System of systems engineering
- Cyber-physical production systems

Prof. Dr.-Ing. Klaus Dröder
Research foci:

- Assembly
- Process automation
- Battery and fuel cell production
- Production technologies

Prof. Dr Stephan Krinke (Honorary professorship)
Research foci:

- Sustainability management in industry
- Life-cycle engineering
- Decarbonization

Institute for Particle Technology (iPAT)

Prof. Dr.-Ing. Arno Kwade
Research foci:

- Mechanical process engineering
- Particle technology
- Battery process engineering
- Pharmaceutical and bioprocess engineering
- Powder and suspension processes

Prof. Dr.-Ing. Sabrina Zellmer
Research foci:

- Sustainable energy storage
- Material and process development for novel batteries
- Hydrogen economy and hydrogen technologies
- Sustainable factory systems and life-cycle assessment

Institute for Surface Technology (IOT)

Prof. Dr. Günter Bräuer
Research foci:

- Thin-film and surface technology
- Low-pressure plasmas
- Magnetron sputtering
- Plasma diffusion processes

Prof. Dr. Michael Thomas (Honorary professorship)
Research foci:

- Interfacial chemistry
- Atmospheric pressure plasma processes

University of Applied Sciences and Arts Hildesheim / Holzminden / Göttingen HAWK

Faculty of Engineering and Health

Prof. apl. Prof. Dr. Wolfgang Viöl

Research foci:

- Laser technology
- Plasma technology
- Plasma medicine

Your contact persons

Institute management, administration and central services

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

Deputy Director
Dr. Lothar Schäfer[2] (until June 30, 2023)
Phone +49 531 2155-520
lothar.schaefer@ist.fraunhofer.de

Deputy Director
Prof. Dr.-Ing. Sabrina Zellmer[3] (as of June 1, 2023)
Phone +49 531 2155-528
sabrina.zellmer@ist.fraunhofer.de

Administration management
Ass. Iur. Annelie Maria Lambert[4]
Phone +49 531 2155-519
annelie.lambert@ist.fraunhofer.de

Sustainability and life-cycle engineering
Prof. Dr. Stephan Krinke[5]
Phone +49 531 2155-504
stephan.krinke@ist.fraunhofer.de

Business development and strategy
Assistant Head of Institute
Dipl.-Ing. Carola Brand[6]
Phone +49 531 2155-574
carola.brand@ist.fraunhofer.de

Marketing and communications
Dr. Simone Kondruweit[7]
Phone +9 531 2155-535
simone.kondruweit@ist.fraunhofer.de

IT
Andreas Schlechtweg[8]
Phone +49 531 2155-633
andreas.schlechtweg@ist.fraunhofer.de

Technical services
Stephan Thiele[9]
Phone +49 531 2155-440
stephan.thiele@ist.fraunhofer.de

Departmental, group and team management

Process technology and production engineering for sustainable energy storage systems

Prof. Dr.-Ing. Sabrina Zellmer[3]
sabrina.zellmer@ist.fraunhofer.de | Phone +49 531 2155-528

Material and process development
Dr.-Ing. Sebastian Melzig[10]
sebastian.melzig@ist.fraunhofer.de | Phone +49 531 2155-795
Product development and design / Production and conditioning of energy storage materials / Production of battery components (electrodes, separator) / Reconditioning and recycling / Material and process simulation

Sustainable process chains for battery systems
Nikolas Dilger M.Sc.[11]
nikolas.dilger@ist.fraunhofer.de | Phone +49 531 2155-660
Planning, modelling, simulation of process chains and factories / Digitization of production / Sensor technology for energy storage systems / Product life-cycle analyses (technical, economical, ecological, social)

Sustainable hydrogen systems and technologies
Christoph Imdahl M.Sc.[12]
christoph.imdahl@ist.fraunhofer.de | Phone +49 531 2155-669
Digital methods for energy conversion chains and sustainable factory planning / Manufacture and recycling of fuel-cell components, modules and systems / Automated assembly and testing of fuel-cell stacks

Interfacial chemistry and adaptive adhesion

Prof. Dr. Michael Thomas[13]
michael.thomas@ist.fraunhofer.de | Phone +49 531 2155-525

Atmospheric pressure plasma processes
Dr. Kristina Lachmann[14]
kristina.lachmann@ist.fraunhofer.de | Phone +49 531 2155-683
Plasma polymerization and chemical functionalization / Process and source development for atmospheric pressure plasmas / Surface cleaning and chemical analysis / Additive manufacturing processes

Electroplating and wet-chemical processes
Rowena Duckstein M. Sc.[15]
rowena.duckstein@ist.fraunhofer.de | Phone +49 531 2155-619
Plastic metallization / Electrochemistry with ionic liquids / Dispersion deposition / Electroplating 4.0 / Pretreatment and recycling

Medical and pharmaceutical systems
Dr. Kristina Lachmann[14]
kristina.lachmann@ist.fraunhofer.de | Phone +49 531 2155-683
Individualized pharmaceutical production and packaging technologies / Medical technology solutions (cleaning and sanitation, protective equipment, implants, disposables) / Quality assurance for manufacturing processes

Optical systems and applications

Dr. Michael Vergöhl[16]
michael.vergoehl@ist.fraunhofer.de | Phone +49 531 2155-640

Precision optical coatings
Dr. Philipp Henning[17]
philipp.henning@ist.fraunhofer.de | Phone +49 531 2155-645
Production technology optical precision coatings / Production of optical layers / Optical online and offline measurement technology

Optical and electrical systems
Dr.-Ing. Ralf Bandorf[18]
ralf.bandorf@ist.fraunhofer.de | Phone +49 531 2155-602
Optical, electrical and magnetic functional layers / Large-area coating / Gas-flow sputtering technology / High-power impulse magnetron sputtering (HIPIMS) / Sensor technology

Simulation & digital services
Dr. Andreas Pflug[19]
andreas.pflug@ist.fraunhofer.de | Phone +49 531 2155-629
Kinetic and CFD simulation PIC-MC / DSMC / Cyber-physical systems / Software development measurement technology

Diamond-based systems and CleanTech

Dr. Volker Sittinger[20]
volker.sittinger@ist.fraunhofer.de | Phone +49 531 2155-512

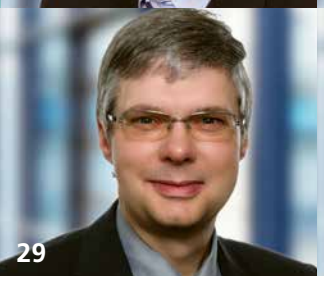
Atomic layer deposition
Dr.-Ing. Tobias Graumann, PMP[21]
tobias.graumann@ist.fraunhofer.de | Phone +49 531 2155-780
ALD for medical products / Coating of 3D substrates for micro-optics and membranes / Particle coating / Catalyst deposition for energy conversion and systems

Hot-wire CVD
Dr.-Ing. Christian Stein[22]
christian.stein@ist.fraunhofer.de | Phone +49 531 2155-647
Application-specific diamond coatings and processes / Solutions for diamond tools and machine elements / Development of HCVD components and production systems / Development of highly efficient solar cells

Photo- and electrochemical environmental technologies
Dipl.-Ing. (FH) Frank Neumann[23]
frank.neumann@ist.fraunhofer.de | Phone +49 531 2155-658
Sustainable methods and systems for air, water and soil treatment and disinfection / Accredited testing laboratory for photocatalytic materials

Analytics and quality assurance

Dr. Kirsten Schiffmann[24]
kirsten.schiffmann@ist.fraunhofer.de | Phone +49 531 2155-577
Chemical and structural analysis / Microscopy, crystal structure and surface measurement / Mechanical characterization / Friction and wear measurement / Testing technology / Customer-specific testing methods / Commissioned investigations



Tribology and sensor technology

Dr.-Ing. Jochen Brand[25]
jochen.brand@ist.fraunhofer.de | Phone +49 531 2155-600

Micro and sensor technology
Anna Schott M. Sc.[26]
anna.schott@ist.fraunhofer.de | Phone +49 531 2155-674
Sensor technology for tribologically stressed systems / Force and temperature sensors / Microstructuring / Data transmission and processing / Sensors for electrical storage and converters

Tribological systems
Dr.-Ing. Martin Keunecke[27]
martin.keunecke@ist.fraunhofer.de | Phone +49 531 2155-652
Resource-efficient and resilient tribosystems / System analysis and evaluation / Carbon layers, hard material layers, diffusion treatments, duplex processes / Process chain including pretreatment and quality assurance

Flexible production systems
Dr.-Ing. Jochen Brand[25]
jochen.brand@ist.fraunhofer.de | Phone +49 531 2155-600
Flexible production systems for surface technology / Interior for mobile applications / Reuse and recycling strategies for components

Dortmunder OberflächenCentrum DOC
Dipl.-Ing. Hanno Paschke[28]
hanno.paschke@ist.fraunhofer.de | Phone +49 231 844 5453
Duplex treatments using plasma nitriding and PACVD technology / Boron-containing hard coatings / Tool coatings / Coatings for hot forming / Industrial knife coatings

Application Center

Dr.-Ing. Jochen Brand[25]
jochen.brand@ist.fraunhofer.de | Phone +49 531 2155-600

Prof. Dr. Wolfgang Viöl[29]
wolfgang.vioel@ist.fraunhofer.de | Phone +49 551 3705-218
Cold plasma spray / Particle coating / Development of production-compatible plasma sources / Particle sorption and modification / Plasma characterization

Fraunhofer Center for Energy Storage and Systems ZESS

Prof. Dr.-Ing. Sabrina Zellmer[3]
sabrina.zellmer@ist.fraunhofer.de | Phone +49 531 2155-528

Prof. Dr.-Ing. Arno Kwade[30]
arno.kwade@ist.fraunhofer.de | Phone +49 531 2155-503
Development of mobile and stationary energy storage and systems / Development and scaling of process technologies / Battery production / Process engineering / Design of the production system for energy storage / Life cycle management

Fraunhofer Center Circular Economy for Mobility CCEM at the Open Hybrid LabFactory

Prof. Dr. Michael Thomas[14]
michael.thomas@ist.fraunhofer.de | Phone +49 531 2155-525
Automated cleaning and preparation processes / Functional and smart surfaces / Use of bio-based and secondary materials / Future interior concepts / Life-cycle engineering and sustainable product design

Highlights

Violet plasma, colorful flames, misty tables

April 28, 2022 / What happens when violet-glowing plasma flames are held against a surface? What causes flames to turn green, blue or red? And how can surfaces be made really clean?

These questions formed the focus of the demonstrations and experiments at the Fraunhofer IST which 20 schoolchildren aged 11-14 were able to carry out as part of Future Day 2022. In addition to a tour of the cleaning plant, they experimented, for example, with colored flames and learned some interesting facts on the subject of flame coloring. Furthermore, 3D-printed pyramids were pre-treated with atmospheric-pressure plasma and subsequently painted.

Visit to the multi-chamber system for aqueous cleaning at the Fraunhofer IST.

Sub-Saharan Africa: Healthcare for everyone

August 17, 2022 / The comprehensive provision of medical care presents a major challenge, particularly in rural regions of Africa. The Fraunhofer IST is therefore working in collaboration with the Fraunhofer Institute for Solar Energy Systems ISE and the Stellenbosch University in South Africa on the development of a mobile healthcare platform with which even the most remote areas can be reached.

True to the motto "Made in Africa for Africa", the long-term goal of the project is the establishment of series production locally in order to create jobs whilst simultaneously enabling local value creation.

Further information on the progress of the project can be found on our website: https://www.ist.fraunhofer.de/en/reference-projects/precare.html

Prototype of the mobile supply unit mounted on a commercial pickup truck. © Fraunhofer ISE; Joachim Went

3

The patient room of the future was officially opened today. Present: (from left) Dr. Andreas Goepfert (Managing Director of Braunschweig Municipal Hospital), Science Minister Björn Thümler, Dr. Thomas Bartkiewicz (Medical Director of Braunschweig Municipal Hospital), Dr. Patrick Hoyer (Research Coordinator Fraunhofer-Gesellschaft), Prof. Dr. Angela Ittel (President TU Braunschweig), Lord Mayor Dr. Thorsten Kornblum, Prof. Carsten Roth (Head of Institute for Structural Design, Industrial and Healthcare Construction), Dr. Kristina Lachmann (Project Manager Fraunhofer IST), Dr. Wolfgang Sunder (Project Coordinator, Institute for Structural Design, Industrial and Healthcare Construction) Prof. Dr. Christoph Herrmann (Head of Fraunhofer IST), Dr. Michael Thomas (Head of Department Fraunhofer IST). © skbs/Björn Petersen

Patient room of the future opened in Braunschweig

August 31, 2022 / Separate bathrooms for all patients, seamless and easy-to-clean bedside tables with dirt-repellent surfaces, automated cleaning concepts, disinfectant dispensers that display a smiley face when used: this is what the "patient room of the future" could look like. The walk-in demonstrator of such a two-bed room was opened on the grounds of the Städtisches Klinikum Braunschweig on 31 August 2022.

The prototype of the patient room was developed in the KARMIN project and exhibited on the Charité premises as part of the World Health Summit 2020 in Berlin. Now the demonstrator is being transferred to a new application-oriented research and study laboratory. The cooperation partners - the Institute for Construction Design, Industrial and Health Care Building (IKE) of TU Braunschweig, the Fraunhofer IST and the Städtisches Klinikum Braunschweig – will thus be able to directly integrate and test research results in a real environment.

The fact that the walk-in model was built on the grounds of the Städtisches Klinikum Braunschweig on Naumburgstraße has a major advantage. It allows medical staff access for practical examinations and the researchers receive direct feedback from doctors, nursing staff and trainees.

For additional information on this topic, please refer to our focus article "Surface technology for the healthcare sector" (starting on page 32) and on our website: https://s.fhg.de/patientroom.

4

Handing over the keys in front of the patient room of the future: (from left) Dr. Andreas Goepfert (Managing Director, Braunschweig Municipal Hospital), Dr. Thomas Bartkiewicz (Medical Director, Braunschweig Municipal Hospital), Dr. Kristina Lachmann (Project Manager, Fraunhofer IST) and Dr. Wolfgang Sunder (Project Coordinator, Institute for Structural Design, Industrial and Healthcare Construction). © skbs/Björn Petersen

A focal point for Fraunhofer

Structural change in the "Helmstedter Revier" through sustainable agricultural production and the digitalization of farming

November 03, 2022 / How can an economic, social and ecologically sustainable structural change be achieved in the former opencast mines near Helmstedt? How can jobs in this region be safeguarded and new ones created? Which innovations are necessary in order to strengthen the agricultural enterprises in the region in the long term? These questions are being addressed not only by politicians and the people and companies of the Helmstedt region, but also by the scientists of the Fraunhofer-Gesellschaft.

On 3rd November 2022, the Fraunhofer Institute for Surface Engineering and Thin Films IST therefore initiated a round-table discussion at Burg Warberg, the headquarters of the Netzwerk Ackerbau Niedersachen (Lower Saxony arable network, NAN). The event was held within the framework of the "Fokusreise Strukturwandel" (Focus journey on structural change), presented by the President of the Fraunhofer-Gesellschaft, Professor Reimund Neugebauer. Against the backdrop of the climate crisis, a growing world population and geopolitical instability, around 30 representatives from politics, science, business and agriculture discussed challenges and solution approaches for today's agricultural systems.

One goal is the optimization of agricultural production with regard to ecological and economic aspects. Accordingly, the focus is increasingly moving towards regional and decentralized solutions that allow optimal adaptation to the respective local circumstances. In order to promote agricultural structural change in the Helmstedt region in an exemplary manner, the Fraunhofer IST, in collaboration with the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, plans to use the Helmstedt location in order to network supra-regional initiatives and regional partners. At the Domäne Schickelsheim in Königslutter, the participants were able to obtain an impression of such technological solutions and the possibilities offered by digital agriculture.

René Borresch, Managing Director of the Federal Training College Burg Warberg; Prof. Dr.-Ing. Christoph Herrmann, Director of the Fraunhofer IST; Prof. Dr. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft; Prof. Dr. Lothar Hagebölling, Member of the Structural Commission Helmstedt; Hilmar Freiherr von Münchhausen, Managing Director of the Netzwerk Ackerbau Niedersachsen e.V.; Volker Hahn, Chairman of the Netzwerk Ackerbau Niedersachsen e.V. (l.t.r.) during the "Focus Journey Structural Change" at Burg Warberg.

The Domäne Schickelsheim in Königslutter.

Tour of the Domäne Schickelsheim: The mobile plant of the Fraunhofer IST is used to produce ozonated water for disinfection.

"Our aim is to develop, in cooperation with the stakeholders, technological solutions for the challenges faced by the agricultural sector and to test them in prototype form. For this purpose, we are pooling the diverse expertise of the Fraunhofer-Gesellschaft and, above all, of the regional partners. These include in particular the TU Braunschweig, the Julius Kühn Institute and the Thünen Institute."

Prof. Dr.-Ing. Christoph Herrmann / Institute Director of the Fraunhofer IST

By means of interactive exhibits, visitors to the exhibition learned what hydrogen is and how hydrogen can make our industry in Lower Saxony more climate-friendly.

At the Hannover Messe, thin-film sensors were presented which record data directly in the high-load zones of tools and components - for improved quality, efficiency and sustainability.

Participation in trade fairs and exhibitions

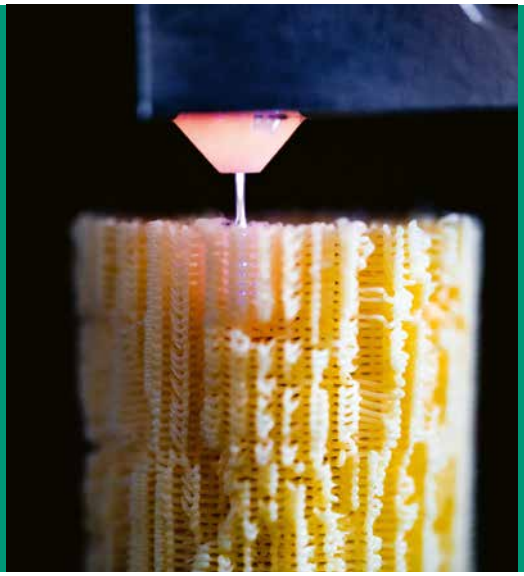
Trade show again, at last - live and in person! After two years of abstinence from trade fairs, the experts of the Fraunhofer IST were underway at numerous trade fairs and exhibitions this year.

From May 2 to 22 in the KonzernForum of the Autostadt in Wolfsburg, the Wasserstoff Campus Salzgitter – under the scientific leadership of the Fraunhofer IST and in cooperation with the Autostadt – presented the exhibition "Energiewende Niedersachen – wie wir mit Wasserstoff unsere Industrie klimafreundlicher machen können" (Energy revolution Lower Saxony – How we can make our industry more climate-friendly with hydrogen). Simultaneously, a four-part series of forum events featuring prominent participants and experts from politics, industry and research was launched on the topic of the chemical element which is regarded as one of the key components for a successful energy revolution.

The focus of the Fraunhofer IST at this year's Hannover Messe was on the subject of thin-film sensor technology. The measurement of force, pressure, temperature, wear and other variables, directly in main load zones or on tool active surfaces by means of thin-film sensor technology, provides valuable data for the optimization of existing production processes or simulation models.

For the optimization of partially or fully lubricated tribosystems such as gear wheels, knowledge of the temperature in the lubrication gap is immensely important. For an improved design of the scuffing load capacity of gears, however, the temperature must be measured directly in the tooth flank contact that is subjected to mixed friction. For the first time, the researchers have succeeded in carrying out a spatially resolved temperature measurement in rolling contacts subjected to mixed friction.

At IFAT, the Fraunhofer IST presented, amongst other things, a mobile ozone generator on the basis of diamond electrodes for the generation of ozonated water on site.



Plasma treatment of a 3D printed scaffold, i. e. a framework structure for a customized implant.

Energy-efficient, resource-saving and environmentally friendly: Pollutant reduction without the addition of chemicals

At IFAT 2022, the world's leading trade fair for water, sewage, waste and raw materials management as part of a joint stand with the Fraunhofer SysWater Alliance, the Fraunhofer IST presented the diamond-electrode-based "DiaDis" system for the production of ozonated water. From May 30 to June 3, visitors were provided with the opportunity of experiencing the "DiaDis" system in operation during the production of ozonated water.

Generating energy with lunar rock

Limited resources on the Moon, the lack of fossil fuels, and extreme conditions such as very high and very low temperatures and a different day/night rhythm necessitate new ideas for energy supply and for the production of the required components and parts. The Fraunhofer IST is developing new concepts in order to secure the energy supply by means of lunar resources, which were presented at the international aerospace exhibition ILA in Berlin from June 22 to 26.

New possibilities for 3D printing through integrated plasma treatment

With the help of atmospheric pressure plasmas, surfaces can be specifically pretreated, cleaned or functionalized. The design of plasma sources is thereby variable and can be adapted to the application: From pinpoint treatments of the smallest surfaces through to the treatment of substrate surfaces of several meters in size, everything is possible. At the Fraunhofer IST, plasma sources are being developed which can be integrated into 3D printers, thereby enabling the targeted chemical modification of the surface during the actual printing process.

This makes it possible, amongst other things, to achieve a significant increase in adhesion, which leads to new options for 3D printed component manufacturing. At K2022 and Compamed in Düsseldorf and formnext in Frankfurt, the Fraunhofer IST demonstrated the plasma treatment of 3D printed components with a prototype of a 3D printer with integrated plasma source.

Award

Fraunhofer IST honored as "Zukunftgeber"

Cordula Miosga, Managing Director of the AGV, presents the certificate with the employer award "Zukunftgeber" to Prof. Dr. Christoph Herrmann, the institute director of the Fraunhofer IST.

June 07, 2022 / In the certification process for the Zukunftgeber award, which is presented by the Employers' Association for the Braunschweig Region (Arbeitgeberverband, AGV), the Fraunhofer IST earned top marks and was rewarded with the Zukunftgeber employer seal.

The institute was audited in a total of ten categories and faced the central questions of flexibility, individual offers and incentives. Overall, top marks were achieved in all nine categories: nutrition and health, attractive earning opportunities, family-friendliness, personnel development and qualification, digitalization, innovation, communication and transparency, mobility and connectivity, scope for development and convenience, and sense of responsibility. Zukunftgeber is an award that particularly attractive employers in the region can receive if they participate in the AGV's certification process.

"We are very pleased that we score points with our attractive working conditions and incentives and that we can also take away valuable impulses for our further commitment."

Ass. Iur. Annelie Maria Lambert, Administrative Manager of the Fraunhofer IST

INNOspace Masters competition – Bronze for "Ferrotherm"

Dr. Franziska Zeitler (DLR), award winner Dr. Andreas Dietz and Dr. Peter Gräf (DLR) (f.l.t.r.) during the award ceremony of the INNOSpaceMasters competition. © DLR

July 05, 2022 / At the INNOspace Masters conference on July 5, 2022, Dr. Andreas Dietz of the Fraunhofer Institute for Surface Engineering and Thin Films IST was delighted to reach 3rd place in the INNOspace Masters innovation competition.

The "Ferrotherm" project, on which the doctorate chemist from the Fraunhofer IST is working together with researchers from the Fraunhofer ICT, was awarded a prize as part of the DLR Challenge 2021/2022. The aim is to develop carbon-free energy generation through iron combustion and electrochemical recycling that can also be used on the moon.

"Very good" for Anton Corba

IHK Braunschweig 2022 examination honors: IHK President Tobias Hoffmann, graduate Anton Corba, training officer Jannik Pfeiffer and HR manager Carolin Buttler (from left to right) following the official award ceremony. © IHK Braunschweig, Andreas Rudolph

October 24, 2022 / Within the framework of the 2022 examination honors, Anton Corba, an apprentice at the Fraunhofer IST, received an accolade for his very good performance in his final examination to become an IT specialist for systems integration.

During the ceremony, the 132 best graduates from the Braunschweig district of the Chamber of Industry and Commerce were honored who, as part of the examination year group, completed the winter examinations of 2021/2022 and the summer examinations of 2022 with the grade "very good". A total of 2650 apprentices successfully completed the examinations.

Furthermore, the Fraunhofer IST – as a training company – received an award during the event in recognition of its commitment to training. Carolin Buttler, a member of the Human Resources department, accepted the award on behalf of the Institute.

"The day-to-day work on our help desk was what I enjoyed the most. There are always new tasks and challenges there. It never gets boring and you learn something new every day."

Anton Corba, IT Specialist for system integration at the Fraunhofer IST

Sustainable solutions in research

Frank Benner, CEO of the B+T Unternehmensgruppe (left), and shareholder Annalina Benner (right) presented the B+T Innovation Award on behalf of the entire group of companies in recognition of the commitment and research work of the Fraunhofer IST in the field of sustainability. Within the framework of the official award ceremony, Institute Director Prof. Dr.-Ing. Christoph Herrmann accepted the prize on behalf of the institute's employees. © B+T Unternehmensgruppe

December 01, 2022 / For its human-centered research and development of sustainable as well as future-oriented technologies, the Fraunhofer IST was honored with the B+T Innovation Award.

The activities of the Fraunhofer IST in the area of Electroplating 4.0 were particularly highlighted. The institute is working, for example, on making electroplating processes more agile, flexible and sustainable in the future through the application of digital methods. For this purpose, modular plant concepts are being equipped with extensive inline, online and atline analytics. Electroplating processes are digitally mapped using software solutions specially developed for automated data acquisition and processing – with the aim of controlling and optimizing the processes on the basis of models, and predicting the required maintenance. In this way, not only are the quality, throughput and reproducibility of the coating processes improved and resource efficiency increased, but the foundations are also laid for a circular economy.

In focus: Surface technology for the healthcare sector

In healthcare facilities such as hospitals or doctors' offices, surfaces play a central role in the transmission of infections. In order to minimize this risk, they must be regularly and thoroughly cleaned and disinfected. This applies to beds, seating, door handles and light switches as well as work surfaces, medical equipment and many other items.

In addition, coatings or modifications to the surfaces themselves can contribute towards improving hygiene and preventing infections. For this purpose, the Fraunhofer Institute for Surface Engineering and Thin Films is developing antimicrobial and easy-to-clean surfaces, environmentally-friendly cleaning systems, and sustainable interior concepts whose application is not limited solely to the healthcare sector.

The "Patient room of the future" in Braunschweig

Patient comfort and secure care are not mutually exclusive. This is demonstrated by the Fraunhofer IST, the Institute for Construction Design, Industrial and Health Care Building (IKE) of TU Braunschweig, and the Städtisches Klinikum Braunschweig in the "Patient room of the future".

The real laboratory was constructed in the grounds of the clinic in 2022. Within the framework of the cooperation, application-related issues with a focus on infection prevention and cleaning in normal care are to be addressed. The emphasis is on the development of innovative, practicable technical construction sample solutions, smart materials and surfaces, and future-proof equipment elements and products. In line with the motto "from bedside to bench and back", new ideas are continuously being implemented in the real laboratory, questions from the hospital's day-to-day practice are transferred to research, and innovative solutions are tested with regard to their practical suitability in the patient room.

To ensure that the ideas quickly find their way into application, the three research partners are working closely together with various manufacturers. Currently, 20 partners are active in the accompanying industry consortium. Further research projects are initiated on a regular basis, thereby taking into account the needs of neighboring sectors, with a view to maximizing efficiency and effectiveness.

Questions which form the focus for the Fraunhofer IST in the "Patient room of the future" are oriented to the following topics:

- Resilient surfaces for infection prevention
- New cleaning and disinfection systems for surfaces and devices
- Recyclability of the utilized materials and processes
- Digitalization

"The 'Patient room of the future' is more than just a room with two beds and two showers."

Dr. Kristina Lachmann, Group Manager at Fraunhofer IST

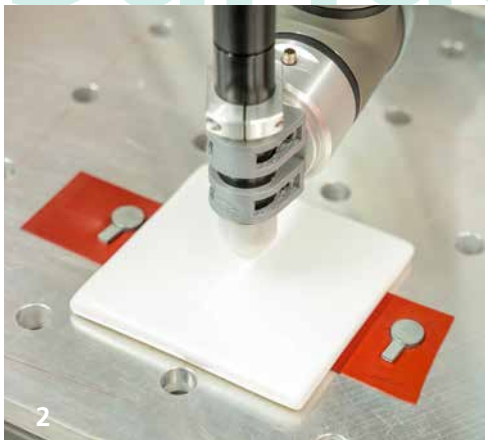
Dirt-repellent coating on a wood veneer.

The surfaces and materials utilized in the patient room play a decisive role, as do the cleaning procedures. The real laboratory contains all the components of a two-bed room for normal care, with the special feature that two showers are integrated. In order to represent the broadest possible spectrum of materials and possibilities for component processing, the showers are designed differently. As a result, the influence of joints or wall seals as well as the use of different materials or designs of bathroom ceramics or fixtures can be examined comparatively.

In the room itself, a variety of materials are used, such as floor coverings made of plastic, wood veneers or imitation leather. The chemical and topographical properties of surfaces play an important role in the adhesion of dirt or microorganisms. The latter can lead to infectious diseases being transmitted from one person to another through contact and smear infections. Particularly in sensitive areas such as hospitals or retirement homes, as well as in public spaces, this can lead to serious infections in immunocompromised, weakened patients. While aerosol-borne germs such as coronavirus are spread by droplets, "heavier" bacteria such as multi-resistant germs often adhere to surfaces or floors.

The materials and surfaces developed – and to be developed – as part of the patient room of the future have great potential for application, including far beyond healthcare and nursing. Durable and robust surfaces that are easy to clean and that become less quickly and heavily soiled, as well as alternative sustainable cleaning processes, are finding a wide range of applications in public facilities, stationary retail, the food-service industry, the passenger-transport sector, and also in private households, among other areas.

Surfaces

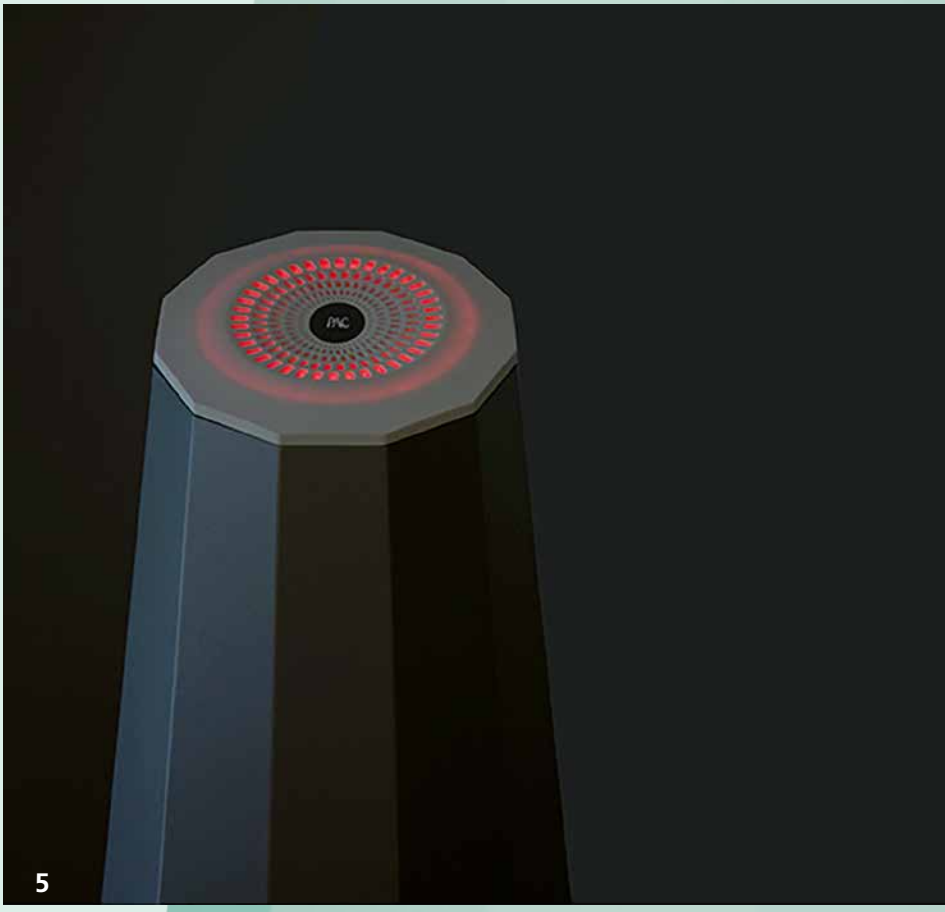


Robot-guided plasma coating of a tile.

Wear-resistant antibacterial coatings on a door handle.

Cleaning

4



5

In collaboration with the HAWK Göttingen and the Fraunhofer WKI, researchers at the Fraunhofer IST have developed an air purifier which combines the advantages of plasma, UV-C and photocatalysis. The "PlasmaAirCleaner" thereby fulfills the function of air purification and, at the same time, enables surface disinfection, for example in hospital rooms. Left: By means of a special "bypass function", the air flowing through the room is able to pass either through the activated carbon or to bypass it. In "activated-carbon mode", all guideline values for gas concentrations in the room must be observed. Right: In "bypass-ozone mode", in contrast, the surfaces in the room are disinfected by the outflowing ozone. A red light indicates the activated-ozone mode.

Cleaning and disinfection are directly connected to infection prevention in hospitals and are defined by hygiene plans that are based on the recommendations of the German commission for hospital hygiene and infection prevention (KRINKO). Depending on, for example, the surface area, existing equipment, the floors or the type of rooms, varying provisions are stipulated here and a variety of chemical cleaning agents are recommended.

The Fraunhofer IST has accrued many years of experience in the development of new plasma sources and the deployment of electrochemical systems on the basis of diamond electrodes. Both can be used for cleaning and disinfection and have the potential of a "green cleaning and disinfection agent". Reactive species for the removal of organic contaminants or the control of microorganisms are obtained in both systems through the utilization of air, water and electricity. In the patient room of the future, investigations will be carried out to determine the extent to which these sustainable and resource-conserving systems can compete with conventional cleaning systems in practice, and whether the material properties of the equipment elements are altered as a result of the processes being used. The potential of the automation of cleaning processes and an integrated quality control system will thereby also be taken into account.

Cleaning and disinfection systems without chemical additives offer a wide range of application possibilities, as do robust easy-to-clean surfaces. Optimal matching of the cleaning system with the surface to be cleaned allows the development of sustainable interior concepts and helps to reduce costs and protect the environment.

Modular plasma source for the cleaning and disinfection of surfaces.

Automated cleaning by means of plasma technology: integration of a plasma source into a robot arm.

Disinfection

Circular Economy

In hospitals, high demands are placed on surfaces and materials in terms of their chemical and mechanical resistance. Nevertheless, it may be necessary to replace, refurbish or extend certain components in rooms.

In collaboration with the architects of the IKE at the TU Braunschweig, the researchers at the Fraunhofer IST want to investigate how patient rooms can be designed on a modular basis. This is relevant, for example, when, as in the case of a pandemic, an increased number of isolation rooms are suddenly needed or, in the event of a disaster, the number of rooms with an increased level of care is no longer sufficient.

Modular room design also promotes the sustainable use of resources. Is it possible to exchange only certain equipment elements? How do these have to be designed, installed or constructed in order for replacement to be cost-efficient in operation? The solutions developed within this context are once again not limited to hospitals. They can also be transferred – tailored to the specific requirements and framework conditions – to other areas, e.g. the interior design of hotel rooms, communal facilities or mobile homes, to name just a few examples.

A modular design with interchangeable elements is one approach for sustainably extending the useful life of existing premises. This is, however, only one aspect. A further aspect concerns the life cycle of the individual products that are installed during the interior outfitting process. The aim is to develop products – from the raw material through to recycling – and the associated processes in such a way that they can be integrated into a circular economy. For this purpose, the Fraunhofer IST implements methods and tools of life-cycle engineering and sustainable factory planning for technical-economic-ecological analyses of product and production systems.

View into the patient room of the future. The beds are hereby opposite each other instead of next to each other.

Digitalization

The long-term goal of the Fraunhofer IST is to create a digital twin of the patient room in order to be able to quickly and cost-effectively test various constellations in advance with regard to the optimum design of the room as well as the processes and conditions within the framework of healthcare research and under the premise of infection control.

Digitalization also provides an important contribution towards progress and sustainability in hospitals. It is an enabler for enhanced energy and resource efficiency, for increased patient comfort, and for a reduction in the workload of staff. Through digitalization, which necessitates appropriate data acquisition, workflows can be improved and, simultaneously, medical care can be optimized. In data acquisition, sensory systems play a particularly important role: firstly, in terms of monitoring the patient status, and secondly, for the continuous determination and optimal adjustment of environmental conditions, such as the room climate.

Digitalization is also directly related to issues of sustainability and the conservation of resources. In the future, the patient room could be equipped with a digital twin in order to enable the rapid and cost-effective advance testing of various constellations with regard to the optimum design of the room as well as the processes and conditions within the context of healthcare research and under the premise of infection control, and in order to record material flows and energy fluxes.

Contact

Dr. rer. nat. Kristina Lachmann
Phone +49 531 2155-683
kristina.lachmann@ist.fraunhofer.de

Tools, plant and mechanical engineering

Vehicle construction

Digital economy

Energy

Tailor-made and sustainable

Our industry solutions for your applications

Aerospace

Medical and pharmaceutical process engineering

Optics

Environmental technology, agricultural and food industry


THOFEHRN
Hebezeuge
FHR Star 400x300

High-tech surfaces as game-changers

Tools, plant and mechanical engineering

Robust and high-performance, smart and resilient – these are requirements which are stipulated on tools, plant and mechanical engineering as well as vehicle construction today. Often, the only option for implementing these demanding goals is the utilization of surface treatments and coatings which are adapted to the materials being used and the conditions under which they are applied.

Individualized, application-specific surface solutions

Tool making, mechanical engineering and plant construction are key drivers of innovation in areas such as Industry 4.0, energy efficiency and electromobility. High demands on service life and resilience as well as the desire for individuality in the field of automotive manufacture necessitate the utilization of new materials and surfaces. The sustainability of the production and the products as well as the implementation in large-scale production must thereby be ensured.

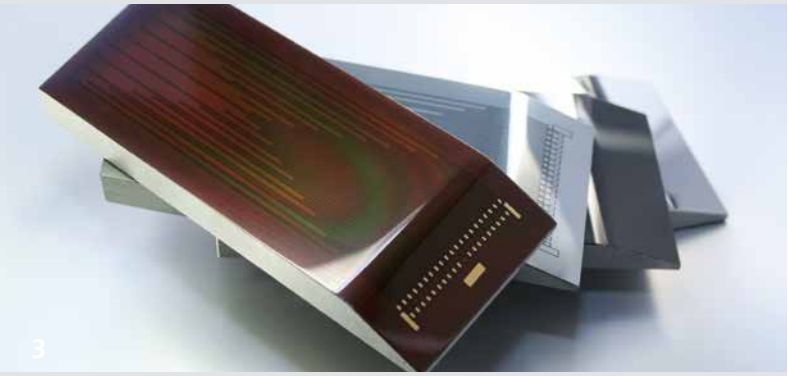
At the Fraunhofer IST, we develop customized application-specific solutions on the basis of a detailed system analysis. We make targeted use of the combination of a wide variety of coating systems and technologies in order to fulfill the varying requirements.

In the process, we are able to realize tribological as well as optical functions and to enable combinations with additional functions such as non-stick or antibacterial properties.

CVD diamond coatings for various component and tool solutions, for example micro grinding pencils, blanking dies or honing blocks.

Photolithographic structuring of the chromium layer, which has a thickness of only 200 nm, on a kingpin. The piezoresistive thin-film system for measuring the load and temperature distribution is deposited directly on the complexly shaped kingpin between the tractor unit and trailer.

The current challenges in vehicle construction, such as the reduction of CO_2 emissions or autonomous driving, necessitate the development of innovative technologies.



Sensor module for monitoring of the draw-in movement of sheet metal during deep-drawing processes.

#WeKnowSolutions

- System analysis and evaluation
- Development of customer-specific solutions
- Broad portfolio of plant technology and coating materials
- Deposition of complex, multifunctional coating systems by means of a wide variety of coating techniques
- Development of individual solutions for the most diverse applications in interior and exterior areas
- Development of smart surfaces and products using thin-film sensor technology for component and vehicle monitoring

In order to satisfy the increasing demands on tools as well as in plant and mechanical engineering, the Fraunhofer IST relies on composites comprised of high-tech materials and material-specific surface finishing. Furthermore, we implement new approaches in surface technology for the design of components which, for example, eliminate the need for lubricants and release agents.

Customized surfaces for the vehicles of tomorrow

The automotive industry is also undergoing a wide range of changes. The increasing trend toward alternative drive concepts and changes in usage behavior with regard to shared mobility are changing the requirement profiles for surfaces for both exterior and interior applications in vehicles. Furthermore, the need for solutions that enable the realization of individual and interactive surfaces is increasing. Autonomous driving also requires the sensor-based monitoring of many vehicle components. Thin-film sensors on surfaces or integrated into components can perform this monitoring function.

Contact

Dr.-Ing. Peter-Jochen Brand
Phone +49 531 2155 600
jochen.brand@ist.fraunhofer.de

From research

Sensor inserts for contact-temperature measurement in cross-wedge rolling process

In the investigation of novel processes for the manufacture of hybrid semi-finished products made from steel and aluminum, the temperature control of the workpiece is of major importance for the resulting component quality. At the Fraunhofer IST, in a project in collaboration with the IPH – Institut für Integrierte Produktion Hannover gemeinnützige GmbH (IPH), thin-film sensor inserts have therefore been developed for integration in a cross-wedge rolling process in order to measure the high contact temperatures during forming. In-process measurement has significant advantages compared to conventional measurement methods such as pyrometry or thermocouples, particularly in terms of accuracy and temporal resolution.

Sensor integration

With the aim of being able to measure the temperature at the tool surface in contact with the workpiece, special sensor inserts have been developed in the form of a so-called measuring funnel, which is integrated into the surface of a flat-die tool. For the read-out of the sensor, the cables can be led out of the back of the machine.

Thin-film system

The measuring principle of the sensor is based on a wear-resistant thermoresistive thin-film system, which is deposited on the head of the measuring funnel. A chromium layer with a thickness of 250 nm is deposited on an insulating base coating consisting of an aluminum oxide layer (Al_2O_3) with a thickness of approx. 4 µm. In a second step, a sensor structure is arranged in a meandering pattern on the measuring funnel by means of photolithography and subsequent wet-chemical etching. The meandering structure is thereby positioned on the horizontal funnel surface, which is in direct contact with the workpiece. The conductor paths for reading out the sensor in four-wire technology are led via a curvature into a chamfered, unloaded contact area. For the cable routing, a channel is recessed into the neck of the funnel. Finally, the thin-film sensor is provided with a second Al_2O_3 layer of approx. 3 µm in thickness, which protects the sensor from wear.

1

Sensor insert coated with thin-film sensors.

Contact-temperature measurement in cross-wedge rolling process

The adjacent schematic diagram shows the sensor positions and the intermediate steps of the cross-wedge rolling process. It can be seen that depending on the material, the workpiece was heated to different degrees before the process. The temperature curve when rolling over the sensor at position A is illustrated in the adjacent diagram. It was possible to show how the sensor can successfully measure and record the temperature in the load zone despite the short contact time with the workpiece.

Outlook: Digitalization and monitoring of production processes

The solution shown here for sensor integration in large machines or tools is an attractive possibility for advancing the digitalization and monitoring of production processes. Through the utilization of sensor inserts, thin-film sensor technology can be implemented for the in-situ detection of temperatures and pressures without the necessity of the complex and cost-intensive coating of entire tools. Furthermore, this approach offers the possibility of improving and further developing the sensor technology through simple replacement and can be applied, in addition to the process shown here, to a multitude of other production processes such as hot and cold forming or plastic injection molding.

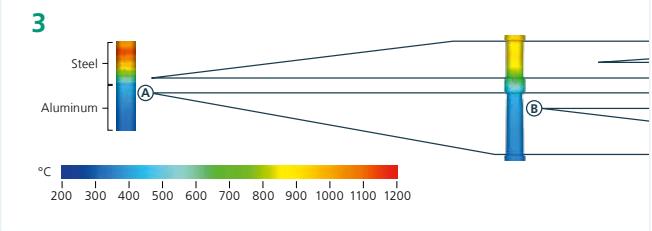
2

Flat-die tool with integrated sensor insert.[1]

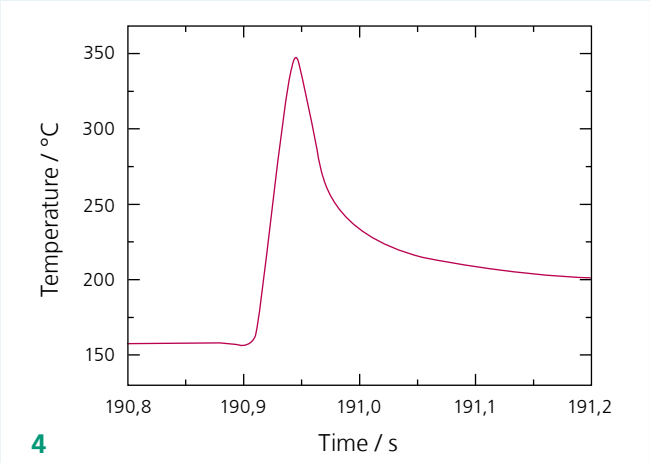
The project

These results were achieved in collaboration with the IPH within the framework of the project "Inkrementelle Umformung hybrider Halbzeuge mittels Querkeilwalzen" (Incremental forming of hybrid semi-finished products by means of cross-wedge rolling) (SFB 1153 – Sub-project B1 – Querkeilwalzen), funded by the Deutsche Forschungsgesellschaft (German research association).

3



Schematic diagram of the tool with measuring positions and workpiece temperatures.[1]



4

Measured temperature profile during a cross-wedge rolling process.

Contact

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

Anna Schott, M.Sc.
Phone +49 531 2155 674
anna.schott@ist.fraunhofer.de

1

Smart screw connection Q-Bo®.

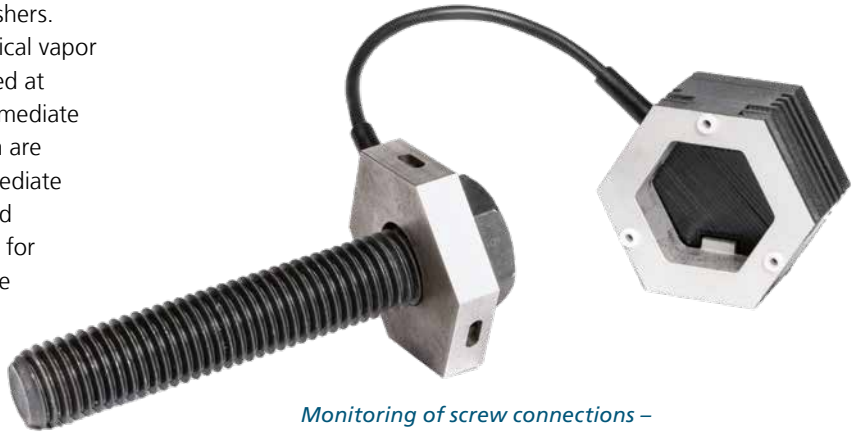
From research

Smart screw connection Q-Bo®

With the aim of realizing wireless and energy-autonomous long-term monitoring of safety-relevant structures such as bridges or wind turbines, the Research Center IoT-COMMs – part of the Fraunhofer Cluster of Excellence Cognitive Internet Technologies CCIT – had already developed the smart screw connection Q-Bo® two years ago. Q-Bo® enables regular monitoring of connections without high expenditure of time and expenses. The thin-film sensor technology developed by the Fraunhofer IST determines the pretensioning force of the screw connection and measures the ambient temperature. Q-Bo® has now been further developed by means of a new mechanical concept; as a result, commercially available DIN fasteners with a size of M18 or larger can be equipped and retrofitted with the sensor system without any major effort.

Sensor design

The integration of the sensor technology into the screw connection is performed at the Fraunhofer IST through the application of a thin-film system to the surface of washers. By means of PACVD processes (plasma-assisted chemical vapor deposition), the piezoresistive DiaForce® film developed at the Fraunhofer IST and the electrically insulating intermediate and top layer SICON® of the multi-sensor layer system are deposited homogeneously on the washer. The intermediate chromium electrodes form the sensor surfaces for load measurement. These structures, as well as a structure for temperature compensation and the meander structure for temperature detection, are produced in photolithographic processes in the clean room.



2

Monitoring of screw connections – wireless, energy-autonomous and retrofittable.

The newly designed electrodes and conductive-paths have been specially adapted for the further-developed mechanical concept of the screw connection in order to achieve a homogeneous force distribution on the electrodes and a compact system design. Simultaneously, the optimized design exhibits improved sensor behavior.

Smart screw connection Q-Bo®

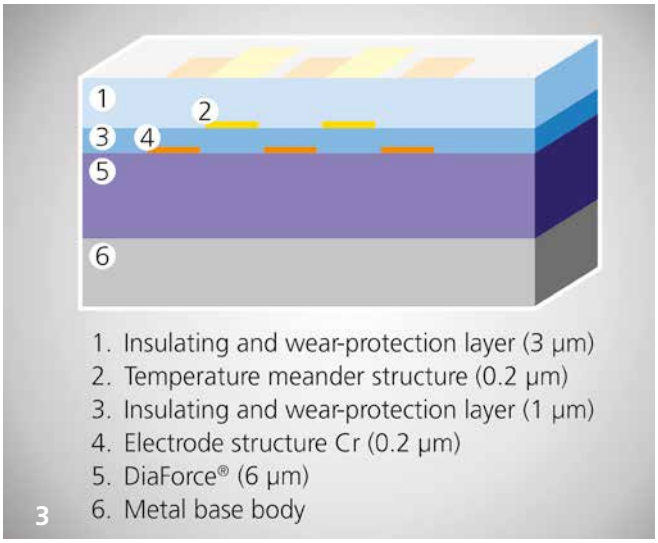
The patented sensor system enables existing screw connections to be upgraded and retrofitted – using standard DIN screws from a size of M18 – for recording the pretensioning forces and the ambient temperature. The evaluation electronics are located in a cap that can be plugged onto the screw head. With the aid of the wireless transmission technology mioty®, measured values are regularly transmitted from the sensor system to a cloud-linked supervisory body. Prior to assembly, the screws are configured in the tamper-proof "FunkeyBox" programming unit and are given their own key. As a result, the sensor data is immune to attack during transmission to the base station or the backend. The autonomous energy supply is based on the energy harvesting principle and can be provided by a thermogenerator, a solar cell or a battery. In order to ensure the assembly and operational use of the Q-Bo® smart screw connection, the mechanical concept was optimized using FEM simulations, and the reliability in terms of tightness behavior and vibration resistance was validated experimentally.

Outlook

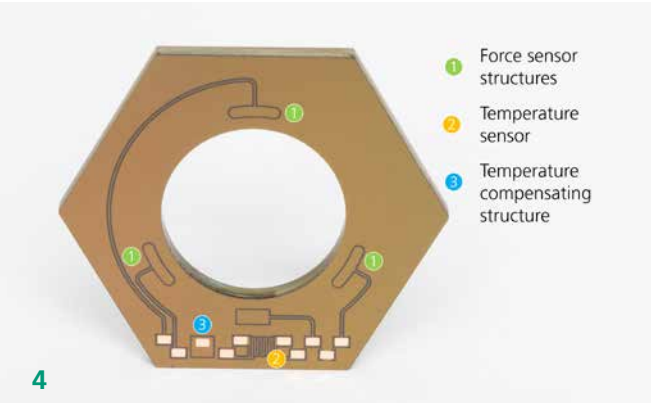
The project results obtained are to be used for the application-oriented optimization of the Q-Bo® smart screw connection. For this purpose, potential users, such as manufacturers and operators of wind turbines, trains, cranes or construction machinery, will be provided with so-called evaluation kits (currently in the sizes M18, M20, M30 and M36).

The project

This patented solution is being developed within the framework of the Fraunhofer Research Center IoT-COMMs in collaboration with the Fraunhofer Institutes IST, IIS, LBF and AISEC. The FIoT-COMMs is part of the Fraunhofer-Gesellschaft's cluster initiative CCIT (Cluster of Excellence Cognitive Internet Technologies).



Schematic diagram of the multi-functional layer system.



Sensory washer.

Contact

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

Anna Schott, M.Sc.
Phone +49 531 2155 674
anna.schott@ist.fraunhofer.de

In realistic industrial setups, the treatability of bearing rings was investigated in batch processes. The batching of individual bearing rings was performed in corresponding fractions.

Treatment of an outer ring tower by means of low-temperature plasma nitriding.

From research

Treatment possibilities for components subjected to tribocorrosive stresses

Sealless rolling bearings that can be used under media lubrication possess high potential for utilization in energy-efficient and resource-saving applications. Standard rolling-bearing materials are, however, of very limited use under these combined stresses of corrosion and wear. A remedy can be offered through edge-zone treatment by means of low-temperature plasma nitriding.

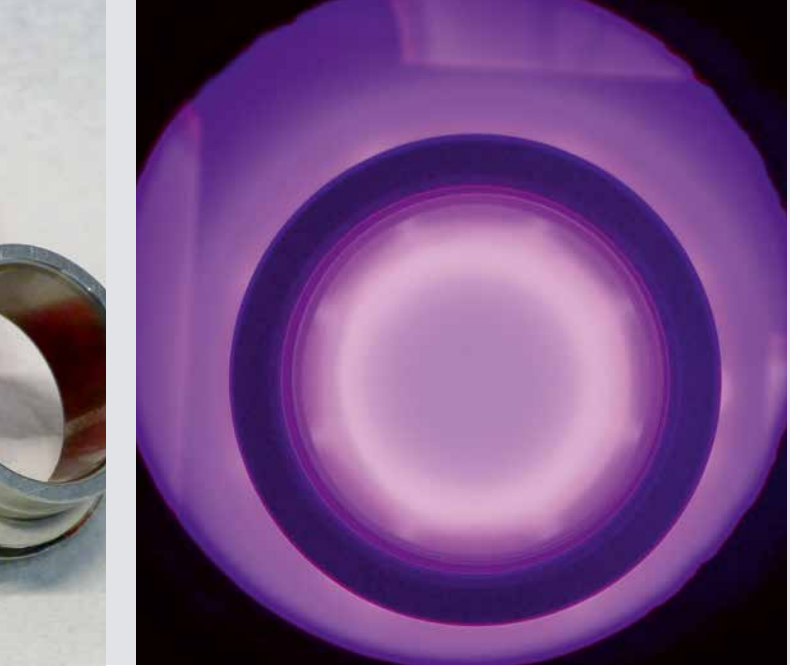
The aim of the POSEIDON-II project, on which the Fraunhofer IST worked in collaboration with project partners, was to optimize the material development initiated in the predecessor project POSEIDON-I and to provide rolling-bearing steels capable of withstanding stresses with regard to mechanical, tribological and chemical-corrosive boundary conditions.

Challenges

In tribocorrosive environments, both corrosion and wear – and the combination of both – play a significant role. In these cases, standard materials exhibit either good corrosion resistance or good wear resistance. For materials to remain resistant within this complex tribological system with corrosion attack, both requirements – high corrosion resistance as well as wear resistance – must, however, be fulfilled. In addition to the corresponding development of treatment solutions on a laboratory scale, the transfer to industrial batch treatment of the rolling bearings is also essential in order to ensure the economic viability of production.

Solution approach

One possibility, through which stainless steels can withstand these stresses, is edge-layer treatment by means of low-temperature plasma nitriding. In this process, nitrogen is dissolved in the interstitials of the material, resulting in an increase in hardness. The advantage of this process compared to a conventional nitriding process is that the low treatment



Treatments were performed on both outer and inner rings.

temperature prevents the precipitation of chromium nitrides, which maintains or even improves the corrosion resistance of the base material. Investigations conducted by the project partner Ruhr University Bochum showed an improvement in tribocorrosion resistance of up to 70 percent for the edge zones produced at the Fraunhofer IST.

Process transfer to industrial scale

In order to be able to implement the advantages of this type of treatment in the application, it is necessary – from an economic point of view – to treat large quantities. With the aim of making the results usable on an industrial scale, investigations were therefore conducted regarding the transfer of process control to industrial scales. Knowledge was thereby gained concerning the homogenization of the process with regard to plasma conditions and temperature and gas distribution, and recommendations for batching were derived.

Outlook

Through this project, a contribution has been made towards the industrial utilization of edge-layer treatment processes. The findings provide the foundation for further optimization and, in addition, demonstrate the potential for application in other industrial sectors. Moreover, the topic field of tribocorrosion, with its complex interrelationships, offers a wide range of additional research opportunities that can contribute towards a better understanding of this system.

The project

The described work was undertaken within the framework of the joint project "POSEIDON-II", funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), as part of the 6th Energieforschungsprogramm (energy research program). The Fraunhofer IST is engaged in the sub-project "Randschichtmodifikation des Grundmateriales, Duplexbehandlungen" (Edge-zone modification of the base material, duplex treatments) (FKZ 03ET1477D).

Contact

Tristan Brückner, M.Sc.
Phone +49 231 844 5464
tristan.brueckner@ist.fraunhofer.de

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

From research

Green-Tools: Cobalt-free carbides with highly efficient CVD diamond and PVD hard coatings for high-performance tools

High-performance tools made from coated carbide play a key role in the German mechanical engineering and the manufacturing industry. Many tools are currently made from tungsten carbide (WC-Co) bonded with cobalt. Both cobalt and tungsten have, however, been listed by the EU as critical raw materials for many years now. In order to address the increasing scarcity of these raw materials and the existing dependence on only a few suppliers and countries of origin, alternative base materials in combination with highly wear-resistant tool coatings have been researched within the "Green-Tools" project.

Indexable inserts with a simple tool geometry for the development of PVD hard coating systems and CVD diamond coatings.

Challenge

High-performance tools are extremely complex and innovative products that are used in the manufacture of almost all technical products. The necessary performance capabilities can only be achieved with "green" technologies if all the competencies involved are optimally coordinated: from the carbide, through the geometry, and on to the appropriate edge-zone and wear-protection coating, as well as the correct processing strategy. For the introduction of new, cobalt-free base materials, the entire process chain of tool manufacturing must therefore be developed and, in particular, precisely matched hard-material and CVD diamond-coating systems and pre-treatments must be researched.

Solution

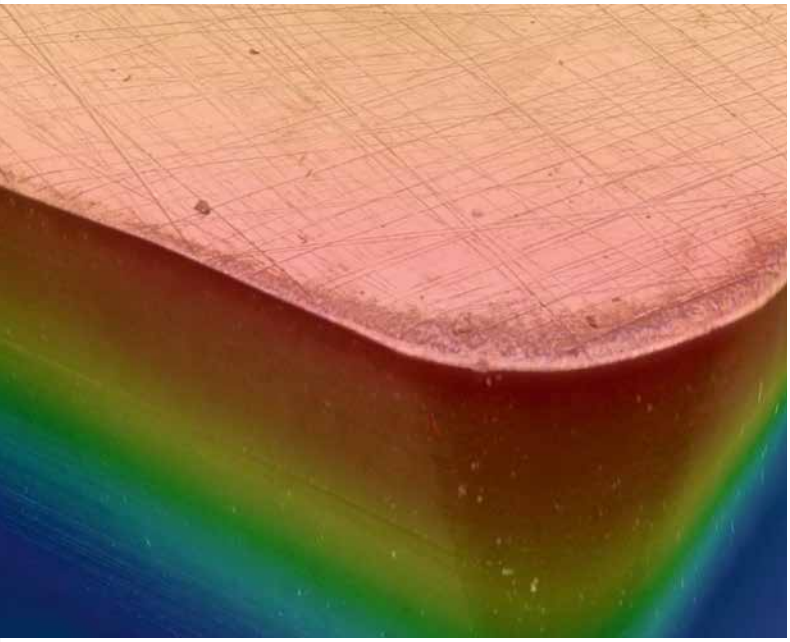
Within the framework of the "Green-Tools" project, the Fraunhofer IST is developing tool-coating systems on the basis of diamond and hard materials for new, cobalt-free carbides with improved composite properties, cutting performance and service life. Our combined process and system expertise is applied here: from tool pre-treatment, through interface design achieved via targeted mechanical and chemical modification of the edge zones - for example with the aid of etching pre-treatments or the application of intermediate layers, and on to the production of innovative diamond and nanostructured hard coatings by means of CVD and PVD processes.

Uses

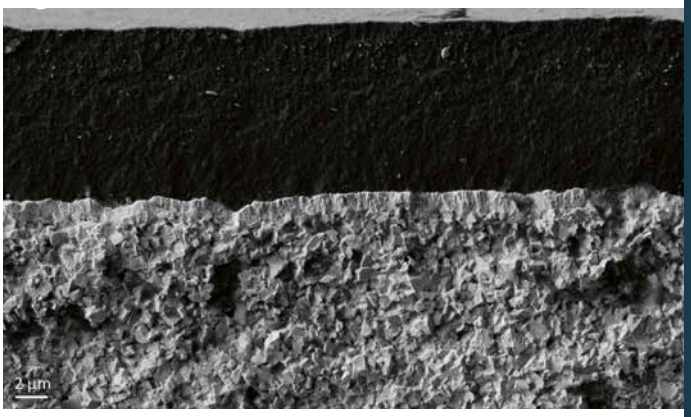
The development of high-performance demonstrators is intended to lower the barrier to market entry, enabling the new technology to be further developed to series maturity with the direct involvement of the key industries of mechanical and plant engineering. As a result, a significant contribution will be made towards the vision of a sustainable and resource-efficient industrial society. The developed pre-treatments and CVD diamond coatings have already enabled a nickel-bonded carbide grade to achieve long tool lives in the turning of aluminum-silicon alloy (AlSi17) that are comparable to the performance of cobalt-containing carbides. By means of a cermet material from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS – which is both Co- and WC-free – in combination with improved hard coatings from the Fraunhofer IST, it was even possible to significantly increase tool life in stainless-steel machining compared with the commercial cobalt-containing reference.

Funding information and collaboration

The results of the "Green-Tools" project were achieved in collaboration with the Fraunhofer Institutes for Ceramic Technologies and Systems IKTS, for Mechanics of Materials IWM, and for Production Systems and Design Technology IPK.



Indexable insert made from alternative base material with an adapted and improved PVD hard coating.



Nanocrystalline CVD diamond coating on a carbide base material. As an alternative to chemical etching treatment, an intermediate layer was applied.

Outlook

The initial results obtained in the coating of cobalt-free base materials with CVD diamond and with nitride hard materials are promising and will be further developed in collaboration with the participating Fraunhofer institutes as well as with partners from industry for specific applications in machining, in particular with regard to the required tool geometries, cutting performance and process reliability. Further target applications, e. g. from forming technology, will also be addressed and materials, treatments and coatings will be researched and optimized for the existing load spetra and application-specific requirements. The aim is to further pursue the developed technology, thereby taking into account raw-material flows during production, recycling and remanufacturing in the context of a closed-loop economy for the sustainable production and industrial utilization of high-performance tools.

Contact

Dr.-Ing. Christian Stein
Phone +49 531 2155 647
christian.stein@ist.fraunhofer.de

Digitalization and data driven product and process optimization for surface technology

Digital economy

Digitalization in surface technology offers a diverse range of potential for optimizing processes, improving the quality of products and production systems, and configuring production processes more flexibly.

Data acquisition and data analytics – the cornerstones of digitalization

The continuously increasing demands on coating products with respect to efficiency, reproducibility and sustainability call for systematic acquisition of product and process data. Digital Twins make use of these data in order to identify the origins for process drifts or defects and to reveal complex interdependencies between different process steps. While in thin film technology, digital twins exist for selected sub-processes, a digitalization of complete process lines is nowadays still a big challenge.

From raw material to high-tech product with innovative process, process and production technology

AAt the Fraunhofer Institute for Surface Engineering and Thin Films IST, we keep an eye on the entire product life cycle and develop sustainable products and associated production systems. Digitization, networking and automation are the keys to a holistic design of process chains and their embedding in production systems. Central to our work is a profound understanding of the relationships between the process parameters, the resulting structure of thin films and surfaces, and the final properties of the product. Inline and laboratory analytics create the foundation for this and provide important data for simulation-based approaches, e. g. for a simulation of layer growth or new data-driven approaches based on machine learning.

All the prerequisites for the experimental validation of data- and model-driven simulation codes are available at the Fraunhofer IST. With these tools, we are able to offer simulation studies for process optimization or knowledge transfer in the form of licenses and workshops. Furthermore, we provide support for digitalization by means of sensor data acquisition, the design and implementation of process and product databases, the selection and installation of high-performance computing hardware and cloud computing.

#WeKnowSolutions

- Innovative simulation solutions in the field of thin film technology in combination with a broad choice of installed process technology and long-term process experience
- Optimization of your coating processes by simulation case studies or by knowledge transfer
- Support in digitalization of industrial production lines, in setting up high performance computing hardware and in cloud computing

Dashboard view of in-situ process data from the cleaning line at Fraunhofer IST.

Contact

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

From research

Simulation of microparticles with PALADIN

In numerous types of application, small particles of differing origins are a problematic factor. This applies in particular to optical applications, in which foreign bodies can impair the optical coatings, but is also relevant in, for example, the field of room ventilation, where microparticles such as dust or aerosols need to be avoided. For this purpose, the Fraunhofer IST has developed the PALADIN simulation software, which numerically models the behavior of microparticles in variable geometries and different situations.

The software

The PALADIN (**P**lasm**A** **LA**ttice **D**ust **IN**tegrator) simulation software was developed in order to investigate the behavior of microparticles in different environments. The original use case was plasma coating equipment, in which particles can cause massive damage and, consequently, reduce production efficiency.

Through the simulation of such equipment with PALADIN, potential sources of danger can be identified and solution strategies can be devised. Furthermore, it is possible to test any hypothetical equipment configurations without having to actually build them. In addition to the geometry of the scenario, the required input parameters of PALADIN include, for example, the flow velocity and the density of the surrounding medium, as well as the starting conditions for the microparticles.

Utilization of PALADIN for optical coatings

One utilization example for the PALADIN software is the simulation of the EOSS® magnetron sputtering coating system. Figure 1 shows a result for PALADIN simulation runs in which a single particle flies back and forth between two targets and a substrate to be coated. It thereby becomes clear that when the particle is in close proximity to the substrate, it is charged particularly strongly by the local plasma and therefore accelerates more strongly. As a result, the risk of a collision with the substrate is increased – and thus the risk of damage.

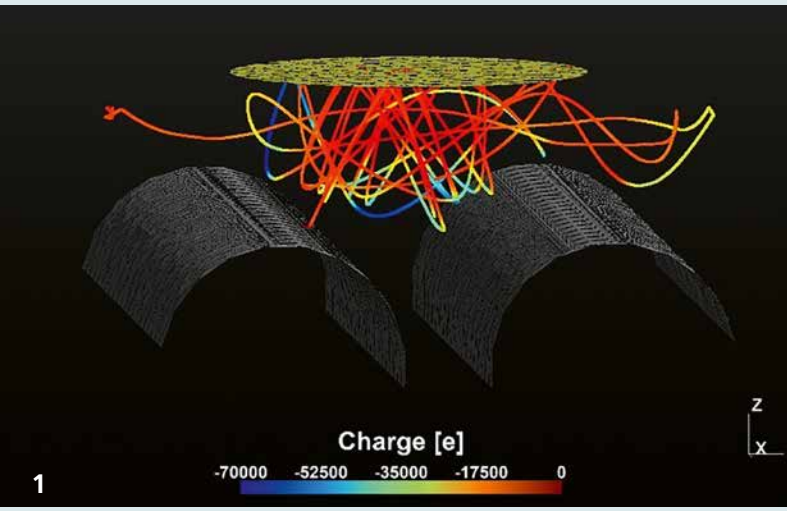
Simulation of air flows by means of PALADIN

A further application example for PALADIN is the simulation of atmospheric air flows. In particular, the simulation of aerosols could be of considerable use in the future, as some viruses such as the corona virus are generally spread in this way. With PALADIN, it is possible to test the risk of infection in various scenarios on the basis of the existing air flows. Figures 2 and 3 depict exemplary simulations of such scenarios: Figure 2 shows the movement patterns of aerosol particles in an idealized hospital room with a ventilation unit, whilst Figure 3 shows an airflow in a pump.

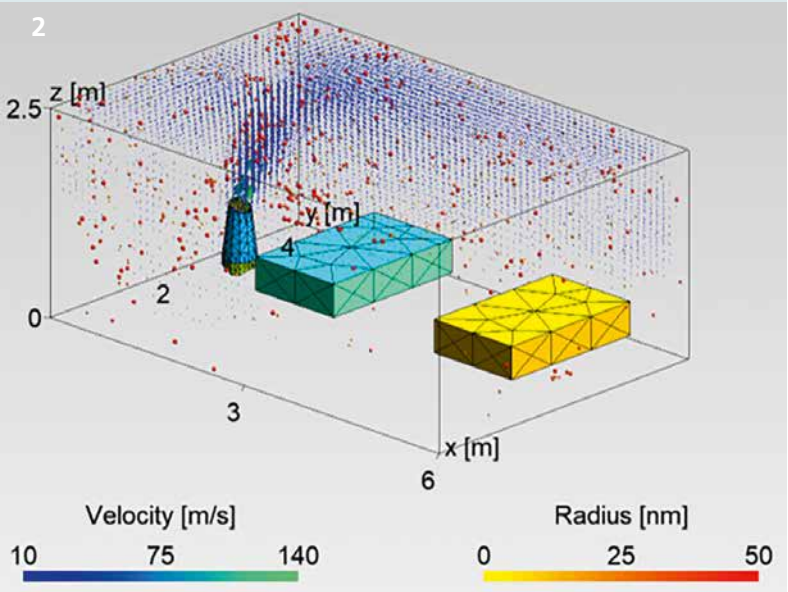
Furthermore, PALADIN can be extended to other potential application purposes, such as for the simulation of particle dispersion within astronomical contexts.

The project

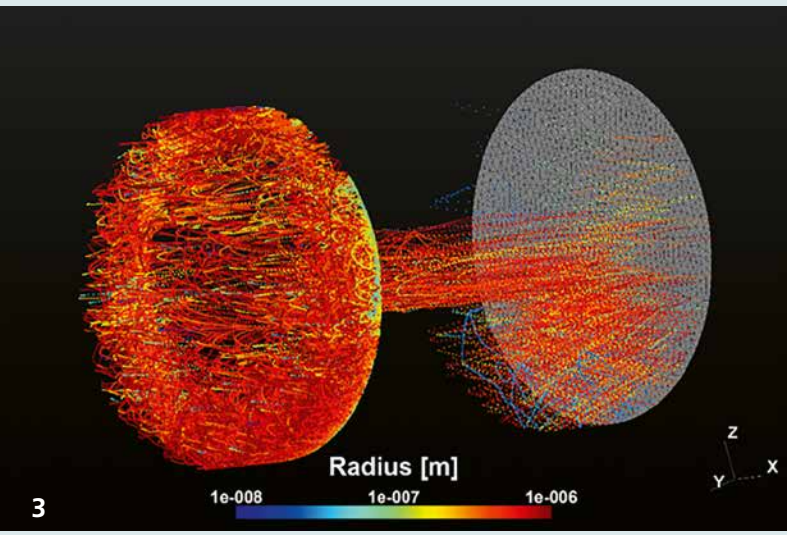
The PALADIN software was developed within the project "EVAPORE – Entstehungsdetektion und Vermeidungsstrategien von Mikropartikeln in Plasmabeschichtungsprozessen für die optische Industrie" (Origin-detection and avoidance strategies for microparticles in plasma coating processes for the optical industry). This is an IGF project (grant number 18590 N) of the Forschungsvereinigung Feinmechanik, Optik und Medizintechnik e. V. (Research association for precision mechanics, optics and medical technology).



PALADIN-simulated path of a particle in the EOSS® system, with particle charge depicted in color.



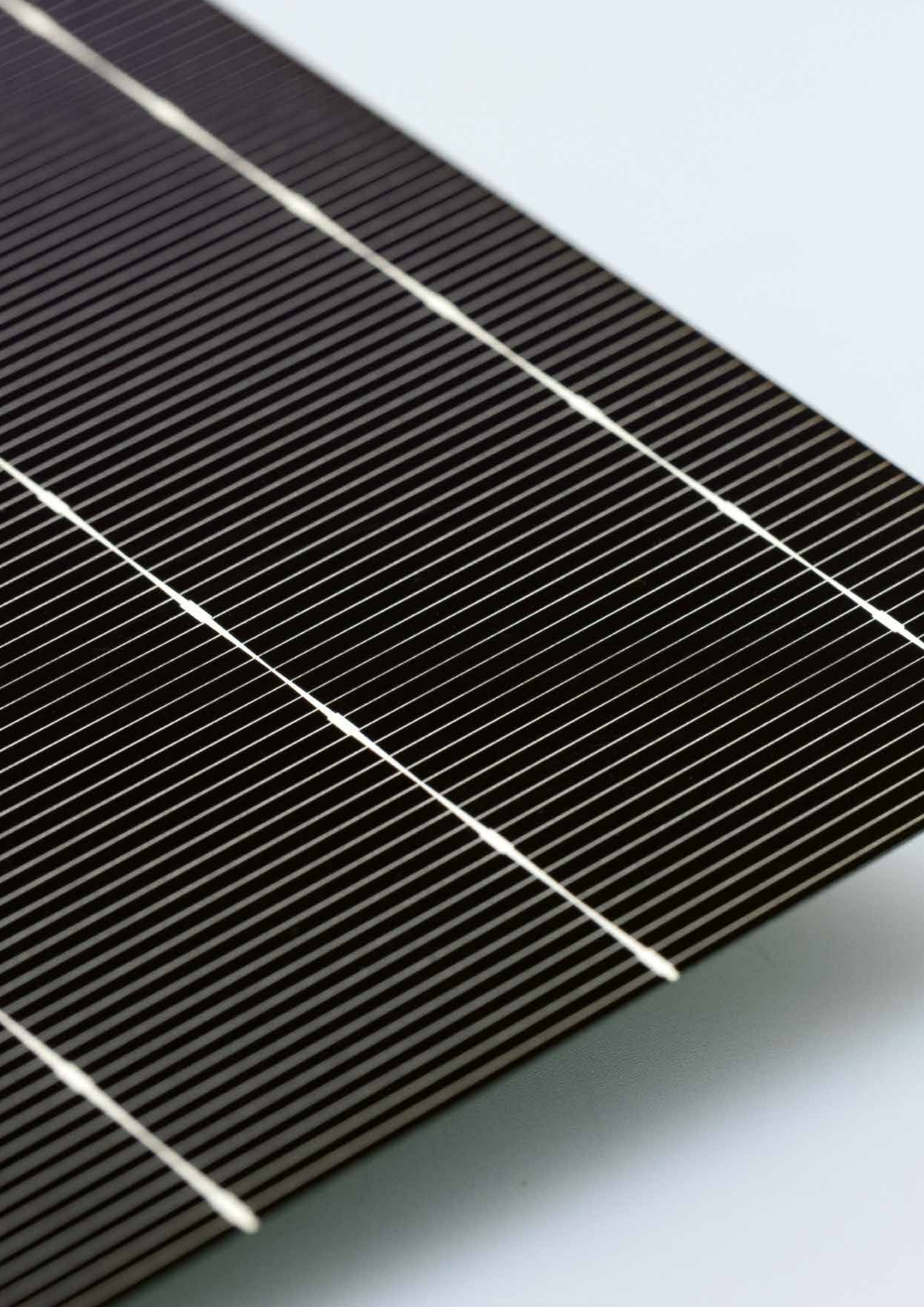
Simulation of the movement of particles in a hospital room with ventilation system.



Simulated movements of particles of differing sizes in a pump.

Contact

Philipp Schulz, M.Sc.
Phone +49 531 2155-668
philipp.schulz@ist.fraunhofer.de



Efficient technologies for a successful energy transition

Energy

One key to the success of the energy revolution is the exploitation of new technologies for the storage of renewable energy in order to enable the transition to a sustainable future.

Silicon layers produced by HWCVD for a heterostructure solar cell.

From photovoltaics to batteries to hydrogen

Nanomaterials for the energy revolution by means of atomic layer deposition.

The de-fossilisation of society and the economy requires a consistent transition towards the integration of renewable energy technologies. However, this can only succeed by developing innovative technologies for energy generation, conversion and storage that are even more efficient, cost-effective and environmentally friendly. Digitalization is supporting this transition by making it possible to intelligently network complex systems, such as producer networks, energy grids or industrial and private energy consumers.

Novel solutions for the energy sector

At the Fraunhofer Institute for Surface Engineering and Thin Films IST, we actively collaborate in order to advance energy research in a wide range of areas. Our main focus is on the development of innovative and sustainable battery technologies based on solid electrolytes (All-Solid-State Batteries, ASSB) and recyclable raw materials. In addition to battery production, we also focus on the development of efficient recycling techniques in order to close the material loop. In the field of photovoltaics, we ensure ever greater efficiency of solar cells with the development of functional coatings and layer systems produced by means of new and industrially established processes.

We are also involved in developing hydrogen technologies that are market-ready by optimizing coating systems for components such as electrolysers, fuel cells or hydrogen tanks. Furthermore, we solve systemic problems such as industrial hydrogen supply and the implementation of sector coupling. Together with strong partners from industry and science; the Fraunhofer Center for Energy Storage and Systems ZESS, the Battery LabFactory Braunschweig (BLB), the Hydrogen Campus Salzgitter and the Open Hybrid LabFactory (OHLF), we drive energy research forward.

#WeKnowSolutions

- Access innovative coatings for optimized components and systems in the energy sector
- Gain knowledge in and contribute to the development and scaling of production processes for novel battery systems
- Participate in the development of recycling strategies for the complete closure of material cycles
- Work with experts in sustainable design of products and processes – from energy generators to energy storage systems
- Contribute to the coupling of production and energy systems of the future

Electrodes for the production of battery cells.

Contact

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

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

1

On the factory premises of Salzgitter AG, green hydrogen and electricity are already being generated from wind energy. © Salzgitter AG

From research

Short-term solutions for green hydrogen in Salzgitter

Germany and the EU increasingly require green hydrogen for the rapid decarbonization of industry. A marketable supply by 2030 can be achieved through a combination of national production and strategic imports by sea. The Wasserstoff Campus Salzgitter, which the Fraunhofer IST is supporting from a scientific perspective, is investigating the essential issues and providing answers regarding the necessary market launch.

Salzgitter as a model region for climate-neutral industry

The Wasserstoff Campus Salzgitter, at its industrially dominated location, is pursuing the goal of developing itself as a prominent model region for the successful transformation of industry and society to climate neutrality by addressing and driving forward the development of a hydrogen economy. On behalf of the Campus, experts from the Fraunhofer IST, in collaboration with MAN Energy Solutions SE, have published a thesis paper on the "GreenH2SZ" project which identifies possible solutions for supplying Salzgitter with green hydrogen in a timely and cost-efficient manner. The research results verify that Lower Saxony offers the best location conditions for the establishment of a competitive hydrogen economy.

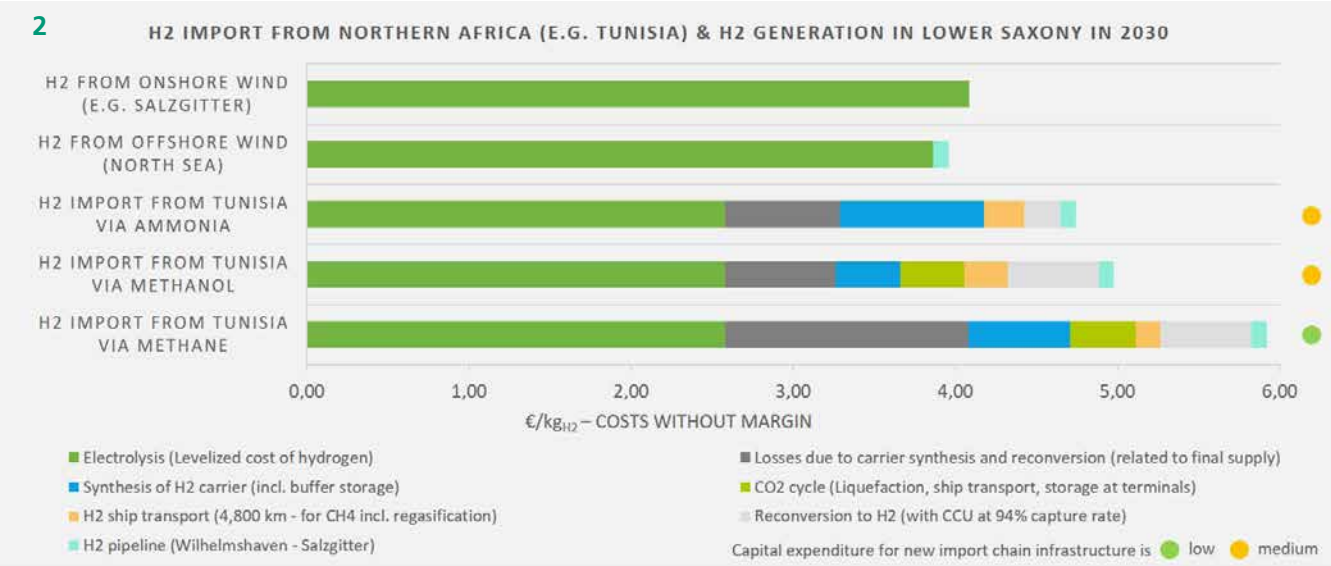
Thesis: The production of green hydrogen in Germany is competitive

One statement in the thesis paper concerns the production costs of green hydrogen in Germany. Although it can fundamentally be produced much more cheaply in sunny countries than in Lower Saxony, it must, however, be converted for transportation to Germany and later converted back again. These processes, which involve costs and losses, force up the total expenditure and exceed the costs for production and transport within Northern Germany. The investigations conducted by the team of experts revealed that hydrogen generated with wind power and transported by pipeline to Salzgitter remains more cost-effective in comparison.

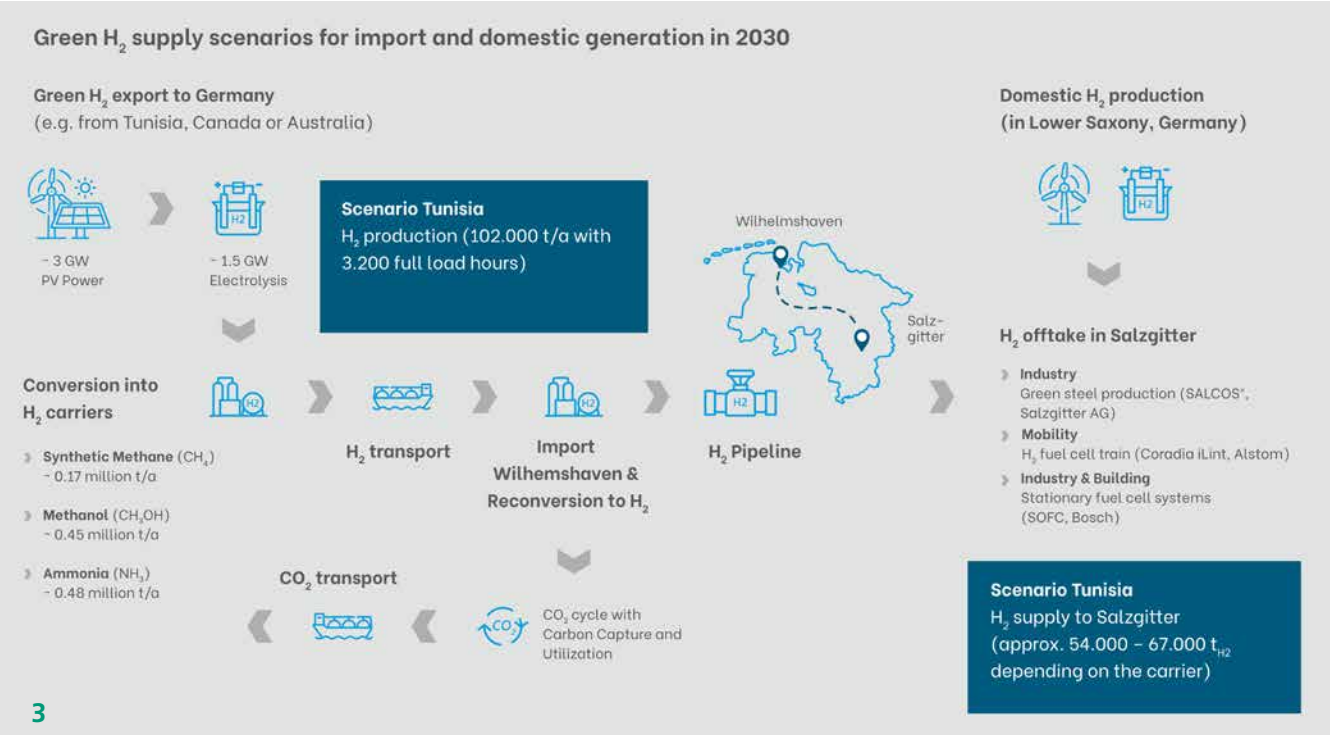
One example: The production costs of green hydrogen from Northern Germany are predicted to be around 4 €/kg H_2 in 2030. In the thesis paper, a comparison with imported hydrogen from Tunisia is provided (see Figure 2, page 66): The costs for hydrogen imported via the so-called ammonia route, i.e. bound in ammonia for transport and subsequently converted back (see Figure 4, page 67), are calculated at approx. 4.70 €/kg H_2. Accordingly, green hydrogen from Northern Germany would be competitive with imports and could form the foundation stone for a sufficient supply. The experts therefore urge for investments in large-scale electrolysis plants and renewable energy production in Germany to be expedited in parallel to imports.

Regional hydrogen production and infrastructure for hydrogen imports necessary

In summary, the authors of the thesis paper conclude that Lower Saxony as a whole offers excellent conditions for initiating and accelerating the market launch of the hydrogen economy for the energy revolution. This applies both to the necessary domestic generation at competitive production costs of approx. 4€/kg H_2 and to the realization of timely imports of green hydrogen via the gas import terminals being built at the North Sea. This corroborates their thesis that Lower Saxony will form the nucleus of the German hydrogen-pipeline network in order to be able to supply industrial sites such as Salzgitter.

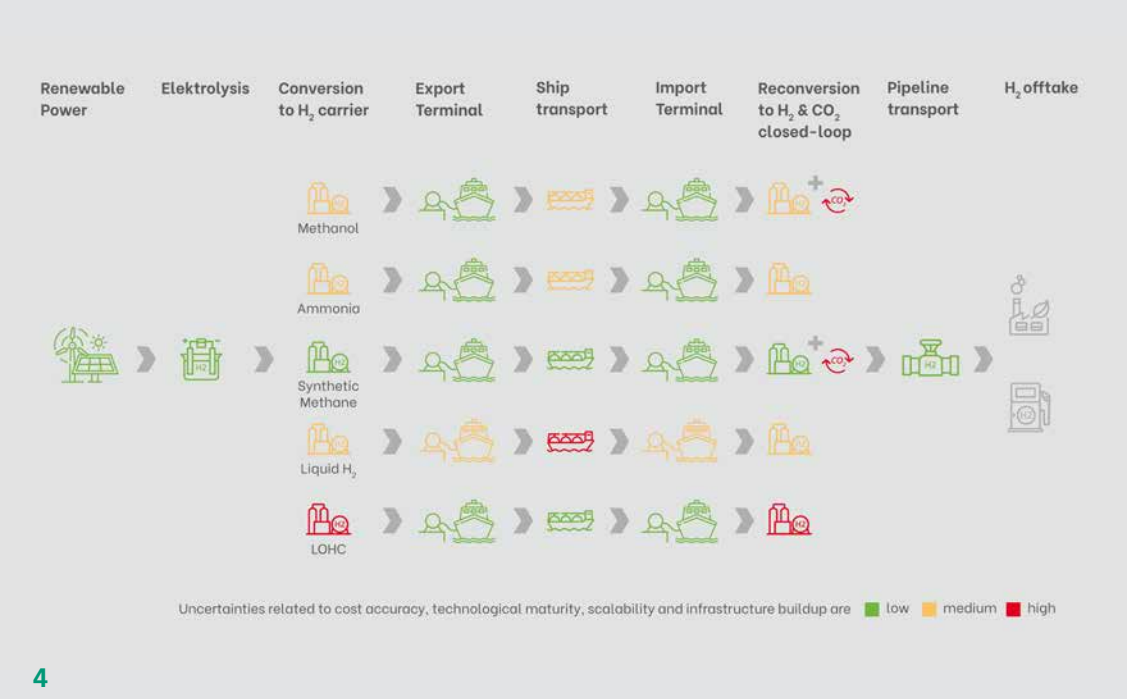


Scenario results: Cost of import supply chains in 2030 for an H_2 supply in Salzgitter in the Tunisia scenario compared to hydrogen production costs from offshore and onshore wind for electrolysis sites in Lower Saxony in 2030.



3

Modeling of the 2030 scenarios for H_2 imports with differing carrier media for H_2 offtake in Salzgitter, taking Tunisia as an example.



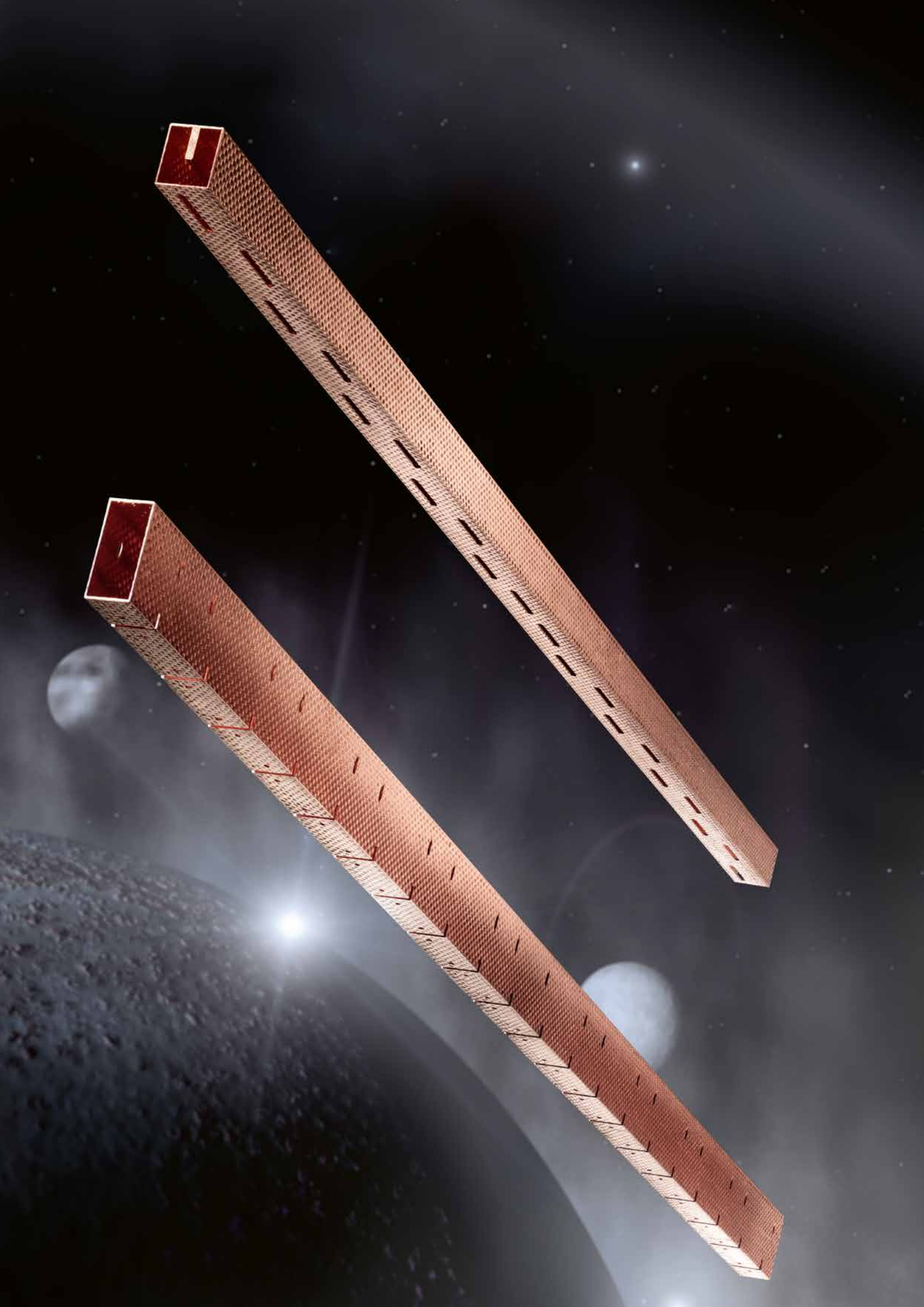
4

Technological maturity and market availability of the respective technologies and infrastructure for future hydrogen supply chains.

Contact

Florian Scheffler, M.Sc.
Phone +49 175 8712948
florian.scheffler@ist.fraunhofer.de

Christoph Imdahl, M.Sc.
Phone +49 531 2155-669
christoph.imdahl@ist.fraunhofer.de



Surface technology for the aircraft of the future and space research

Aviation and space travel

Aircraft and spacecraft must function reliably under the extreme conditions encountered in aviation and space travel. Research and development into surface technology is therefore focusing on, amongst other things, innovative materials that can withstand the severe temperature fluctuations, pressure changes, and severe corrosion and friction, whilst simultaneously being lightweight, high-performance and cost-effective.

Fraunhofer IST scientists are able to apply a metall coating on carbon-fiber reinforced plastic antennas for the ESA "Sentinel-Mission".

The future of the earth lies in the stars

The demands placed on new developments in the aviation and space travel sector have a great deal in common: One important goal, for example, is to reduce emissions of harmful gases. Furthermore, the industry places high demands on the materials being utilized, particularly with regard to the replacement of critical substances or raw materials. The Fraunhofer IST therefore develops and implements a diverse range of solutions for aviation and space travel applications.

Active exploration of space serves not only the study of fundamental laws of physics but also real applications such as the investigation of living conditions on distant planets. With the construction of the ESA "Moon Village", plans are being made to send people to the Moon for a longer period of time in order to conduct research there. To make this possible, at the Fraunhofer IST we employ (electro-)chemical processes in order to, for example, extract usable metals and vital oxygen from lunar regolith. In addition, we are developing processes which will enable energy storage systems and fuels to be produced from lunar material. For almost all of today's missions, optical instruments are also important. With the aid of hyperspectral cameras from orbit, for example, the condition of the Earth's atmosphere can be recorded very precisely. Furthermore, the radar antennas of the Sentinel-1 mission, which were coated at the Fraunhofer IST, measure the Earth's surface extremely accurately.

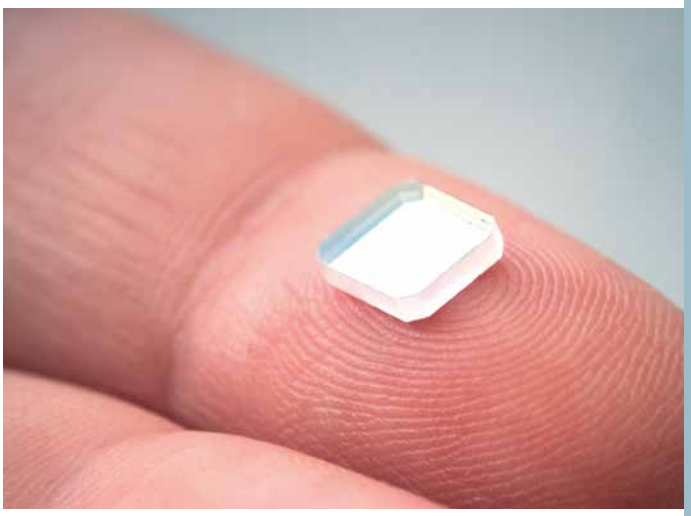
At the Fraunhofer IST, we realize space-specific optical precision coatings using the latest coating processes at a high technology readiness level (TRL).

Our contribution towards green aviation

In the field of aviation, we utilize our expertise in the modification and design of surfaces in order to develop solutions for the substitution of critical substances such as cadmium (Cd) or Cr(VI). The vision of emission-free aviation leads to a radical change in the development of aircraft as well as their energy storage systems, and therefore necessitates a systemic approach for the utilization of new material systems and adapted processes as well as the evaluation with regard to the contribution towards emission reduction. In collaboration with our customers and partners, we are therefore working on the further development of energy storage systems and converters such as the interior coating of hydrogen tanks, solid-state batteries and fuel cells.

For applications in the interior of vehicles, we functionalize surfaces in order to, for example, equip them with integrated sensor technology for the realization of smart systems, or with antibacterial coatings. For the optimization of the aircraft in terms of their structure, we are working on the improvement of joint connections, on the anti-reflective coating of windshields, and on ice-free surfaces.

Fabrication steps in the thin-film sensor system from front to back: sensor module with electrode structures, a sensor module with a complete coating system, and a module with an electrically isolating coating on the back.



Technology from the Fraunhofer IST on Mars: The interference filter (right) is a component of an optical sensor for dust characterization in the "Mars Environmental Dynamics Analyzer", or MEDA for short.

#WeKnowSolutions

- Experience in space projects, e.g. ESA Sentinel-1, DLR MASCOT, ESA BepiColombo
- Scientific-technical expertise in the field of materials for lightweight construction and surfaces, in particular in the field of In-situ-Resource-Utilization (ISRU) as well as for production
- Development of models for subsequent terrestrial use
- Development of materials and processes in the fields of surface technology, sensor technology, energy storage, and lightweight construction
- Systemic consideration of materials, production and life cycle engineering
- Transfer of expertise from research into industrial application
- Complementary services in the field of analytics, quality assurance and documentation

Contact

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

Dr.-Ing. Peter-Jochen Brand
Phone +49 531 2155-600
jochen.brand@ist.fraunhofer.de

From research – Interview

Resource extraction on the Moon

Living on the Moon? This may perhaps sound somewhat unrealistic today, but the urbanization of the Moon is one of the future topics in space travel. Limited resources on the Moon, the lack of fossil fuels, and extreme conditions such as very high and very low temperatures and a different day/night rhythm necessitate new ideas for energy supply and for the production of the required components and parts.

The Fraunhofer Institute for Surface Engineering and Thin Films IST is developing new concepts in order to secure the energy supply by means of lunar resources. An interview with Dr. Andreas Dietz, expert in electrochemistry and surface engineering for the astronautics sector at the Fraunhofer IST.

Dr. Dietz, you are intensively involved in the subject of "electrochemistry in astronautics". What is it about this subject that fascinates you so much?

Well, we want to save the world, and the best place to start is on the Moon. As was the case back in the 1960s and 1970s, people today want to fly to the Moon again. Back then, it was the Apollo mission that had the world on tenterhooks. Today, people are again seriously thinking about putting humans on the Moon, but for a longer period of time.

In the "Moon Village" project, we are working on the goal of building an entire village on the Moon. One big challenge, however, is that there is nothing on the Moon: no variety of materials, and, unfortunately, no hardware store where you can shop to your heart's content. So we have to work with what is available up there. Developing technologies and researching methods that make this possible is an exciting field of work.

Is living on the Moon conceivable in the future?

An important prerequisite for a permanent and sustainable human presence on the Moon is the availability of resources such as pure metals and oxygen in order to create, for example, accommodation, a research station and the necessary infrastructure for astronauts. The so-called lunar regolith, loose rock found on the surface of the Moon, consists of metal oxides such as iron, titanium, aluminum and magnesium. In these oxides, oxygen is present in a tightly bound form and accounts for about 50 percent of the total mass. In order to make both the oxygen and the metals available in their pure form, a process under space conditions with few consumable materials is necessary. At the Fraunhofer IST, we are working on such a process for the extraction of pure elements from lunar regolith.

What are the challenges created by resource extraction on the Moon?

We have to live with the supplies and resources that are available on the Moon. We can only bring up a small amount from Earth because, of course, it will be far too expensive. A kilogram payload for a rocket costs around 15,000 euros, and we can't transport tonnes upon tonnes up there. This means that the major challenge is that everything we need on the Moon – houses, roads, lamps, every single screwdriver – has to be made from this resource: regolith.

What projects are you working on in order to achieve this goal?

One project is ELMORE, which stands for "ELectrochemical Processes for the Extraction of Pure Elements from MOon REgolith" and which was funded by DLR. The aim of the project is to extract usable metals and oxygen from regolith, i.e. we are trying to split regolith in such a way that we obtain iron, aluminum or silicon on one side and oxygen on the other. This is in itself a huge challenge, in particular because the conditions on the Moon are completely different and very difficult.

What conditions are these?

It's bitterly cold at night at -120 °C, while during the day it gets very hot with temperatures of 170 °C. In addition, there is the changed day-night rhythm: A day-night cycle on the Moon corresponds to a period of about one month on Earth. It takes about a week from sunrise to the highest point of the sun, and another week until the sun has set again, followed by a lunar night that lasts about 14 days. For such long nights, sufficient energy must be stored, amongst other things.

How can this be achieved? Do solution approaches already exist for this?

In the DLR "Ferrotherm" project, we are working on the idea of developing carbon-free energy generation through iron combustion and electrochemical recycling. The advantage is that the iron oxide produced during combustion is solid and can be recycled electrochemically. In a later step, this principle of iron combustion is to be transferred to a power plant – analogous to a power plant on Earth. After all, as there are no fossil fuels on the Moon and the available resources are also finite, we have to look for an approach that is also sustainable in the long term. This process could then also be transferred in the medium term to energy generation without fossil fuels on Earth.

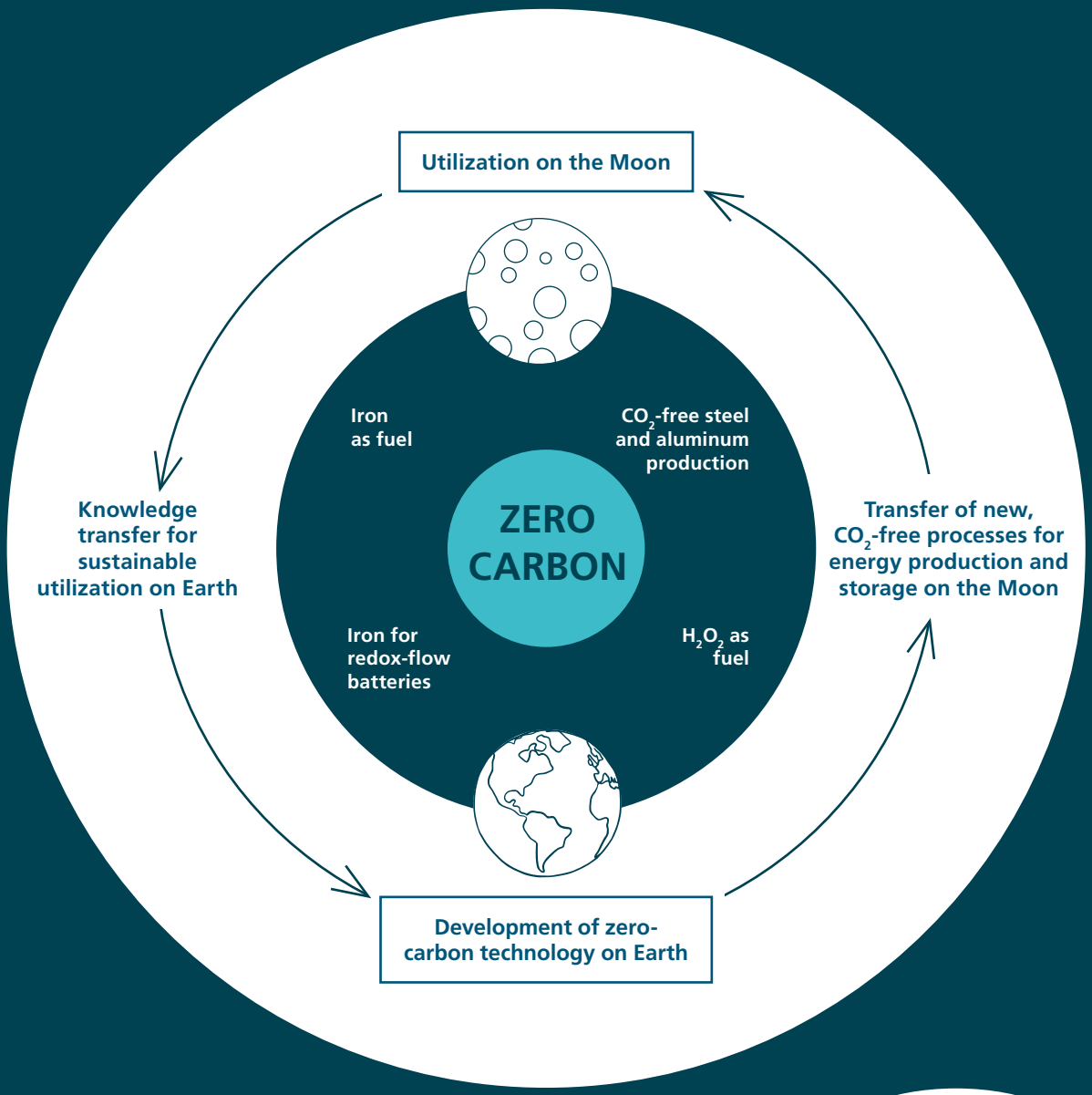
Dr. Andreas Dietz im Interview.

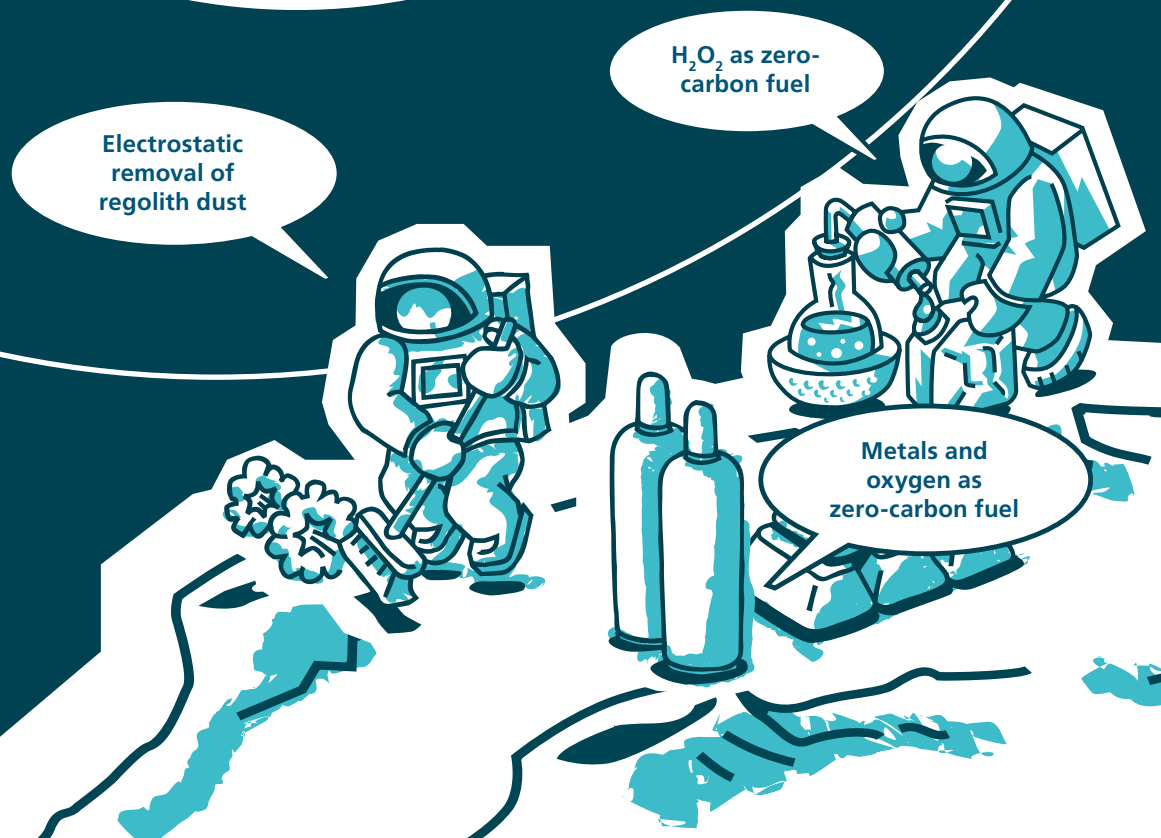
Do you think that – in view of the climate crisis – it makes sense to invest so much money in making the Moon usable as a habitat?

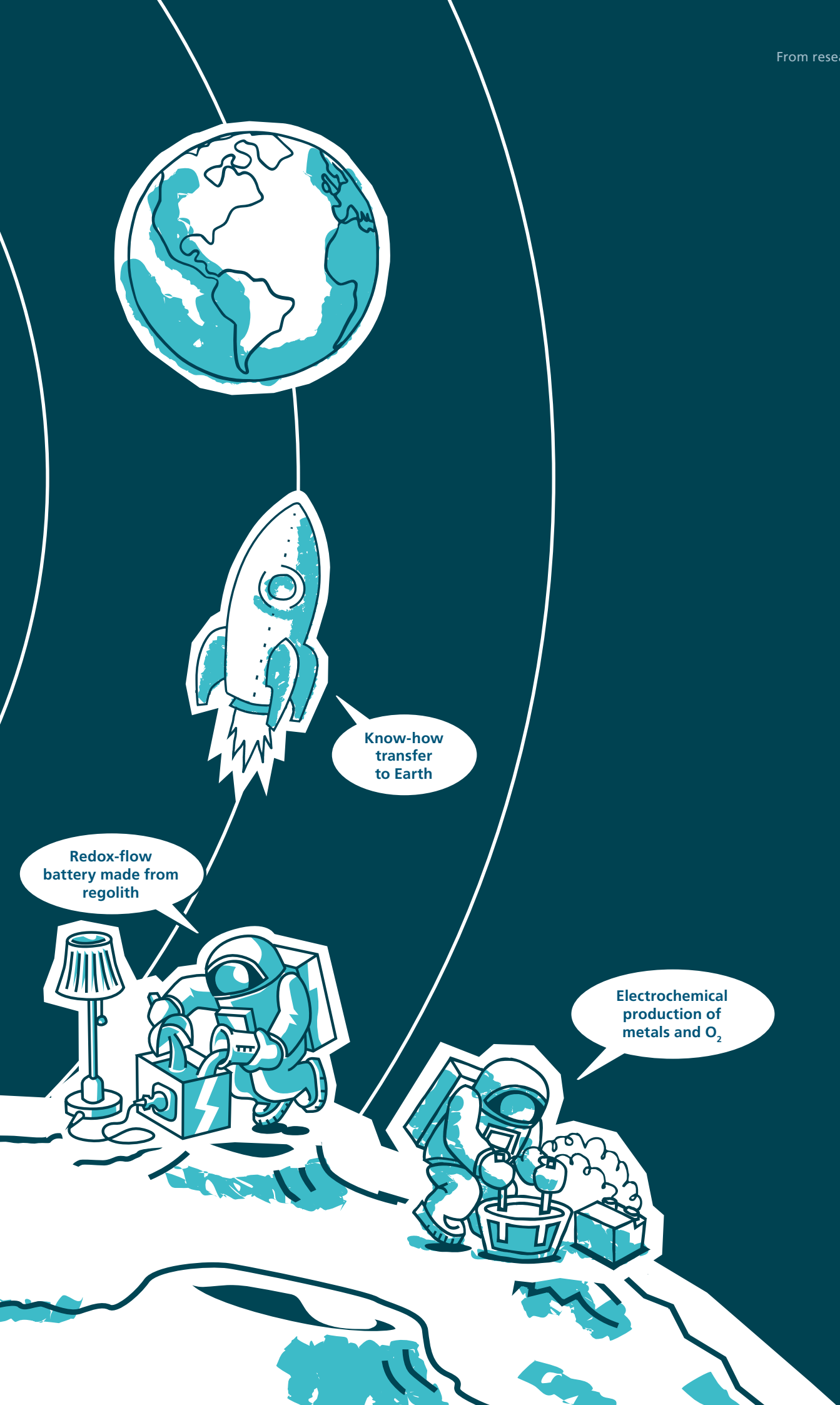
We don't want to just fly to the Moon - we want to use all these ideas and technologies that we are developing for "Moon Village" on Earth as well. That is how we want to accelerate decarbonization. It's just as well that we don't have any carbon on the Moon, anyway; if we can succeed in utilizing iron as a fuel there, then we'll be able to do it on Earth, too. Batteries are a similar example: Useful energy sources on the Moon would be so-called redox-flow batteries, which already exist on Earth. These are based on vanadium, but nobody wants to work with it because it is considered a critical raw material. There is no vanadium on the Moon and one has to make do with what is available: iron, titanium, magnesium. This means that people are now thinking about making redox-flow batteries from iron or titanium in the future and then transferring that to Earth. A battery made from iron would really be a wonderful gift. It's not critical, it's available everywhere, and, furthermore, it's very cheap.

Your conclusion?

These are all ideas that occupy our minds when it comes to developing ISRU (in-situ resource utilization) themes for the Moon. We are primarily concerned with developing sustainable and efficient innovations for space and Earth. The main idea for us is always to facilitate the use of these technologies on Earth as well, in order to be able to work here resource-efficiently, without carbon and, consequently, more sustainably.


Utilization on the Moon
Iron as fuel
CO_2-free steel and aluminum production
ZERO CARBON
Knowledge transfer for sustainable utilization on Earth
Transfer of new, CO_2-free processes for energy production and storage on the Moon
Iron for redox-flow batteries
H_2O_2 as fuel
Development of zero-carbon technology on Earth


Electrostatic removal of regolith dust
H_2O_2 as zero-carbon fuel
Metals and oxygen as zero-carbon fuel


Know-how transfer to Earth
Redox-flow battery made from regolith
Electrochemical production of metals and O_2

Individualized and sustainable

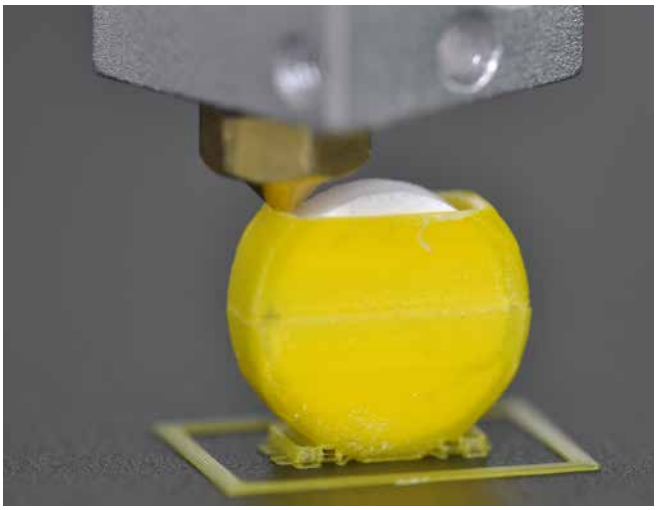
Medical and pharmaceutical process engineering

Coating and surface technologies are an essential key to innovative products for medical and pharmaceutical process engineering. Stringent quality requirements, complex regulatory stipulations, plant-related and operational conditions and, last but not least, digitalization present the industry with major challenges.

Application of plasma technology in the field of medical and pharmaceutical process engineering: By means of plasma treatment, the migration of plasticizers from blood bags can be reduced.

Customized coatings for medical products and production systems

Functionalization of active ingredients and excipients by means of plasma processes for the optimized production of individualized pharmaceutical products.



Use of additive manufacturing for the production of individualized pharmaceutical products.

Optimal patient-centered and individualized care is an important goal in medical and pharmaceutical technology. One current example from research is for tablets or capsules to be designed in such a way that they can be manufactured flexibly in small quantities, i. e. individualized for one patient or a small group of patients.

In interdisciplinary teams, the Fraunhofer IST develops solutions for product and production systems in medical and pharmaceutical process engineering. By means of adhesion-controlling surfaces we optimize, amongst other things, cell-culture systems and implants. With functional coatings, we increase the sensitivity of e. g. diagnostic test procedures. In the field of hygiene, we offer innovative cleaning systems for surface disinfection in addition to sustainable antibacterial coatings.

Consolidated know-how and expertise

In the field of customized medicine production, we work in close cooperation with the Center of Pharmaceutical Engineering PVZ of the TU Braunschweig on pharmaceutical production technologies and product developments within the framework of a translational laboratory. The aim is to mutually accelerate the transfer of research results and innovations into application and to assist partners by acting as innovation pilots. Our focus thereby lies on additive-manufacturing technologies and the modification of active ingredients and excipients in order to improve processing and functionality, as well as the interactions between drug substances and production systems at different industrial scales.

In collaboration with the TU Braunschweig and the Städtisches Klinikum Braunschweig, we are working on a patient room of the future with the aim of developing structural-engineering solutions, smart materials and surfaces, and future-oriented equipment elements and products.

As a member of the Fraunhofer High-Performance Center Medical and Pharmaceutical Engineering, we are working together with the Fraunhofer ITEM and the Fraunhofer IMTE on the design of a platform for research and innovation transfer into patient care. Our focus is thereby directed towards personalized implants and respiratory systems as well as the individualized production of medication.

#WeKnowSolutions

- Acceleration of innovation transfer for individualized medicine production and new packaging concepts
- Equipment qualified for medical technology
- Product-oriented process and source development for functional surfaces, cleaning and hygiene
- Development of materials and cleaning systems in the research and study laboratory of a "patient room of the future"
- Translational laboratory for individualized medicine production
- Individual surface-technology solutions for production plants
- Comprehensive development of process chains for pharmaceutical production systems right through to packaging in cooperation with the PVZ of the TU Braunschweig

Contact

Dr. rer. nat. Kristina Lachmann
Phone +49 531 2155-683
kristina.lachmann@ist.fraunhofer.de

From research

Automated cleaning and pretreatment

The COVID-19 pandemic has clearly demonstrated the importance of quick and easy cleaning and disinfection systems in our everyday lives. In public buildings, medical facilities or in the mobility sector: everywhere, there is an indispensable need for sustainable surfaces which can be cleaned as easily as possible. The Fraunhofer IST is therefore working on the development of automated procedures which are adapted to the surface and the soiling in order to ensure efficient and material-friendly cleaning.

Sustainable solutions for clean surfaces

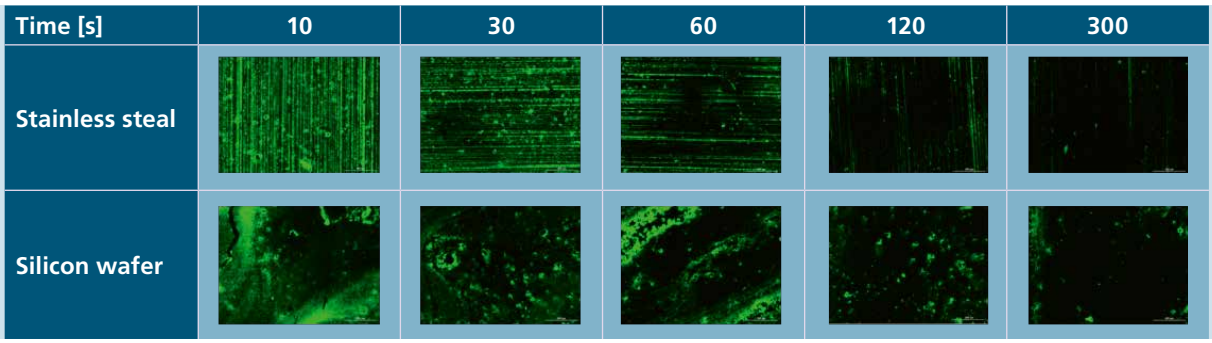
Indoor spaces or the interiors of vehicles are characterized by a high diversity of materials and different geometries. Materials with a high-quality appearance, functional surfaces with touch functions, and textiles are exposed to the most varied stresses and requirements. Optimal cleaning procedures designed to ensure the longevity of the materials and surfaces are extremely complex, as in many cases a different cleaning agent has to be used for each surface. This causes high costs, major environmental pollution and often also leads to errors that can result in irreversible damage to the surfaces.

Multifunctional surfaces and innovative self-sufficient cleaning systems

At the Fraunhofer IST, we offer customer-specific solutions for multifunctional surfaces which possess, for example, antimicrobial, dirt-repellent or flame-retardant properties. We thereby employ comprehensive surface analytics and are therefore able to evaluate, amongst other factors, the layer composition and stability as well as wetting and microbiology. In addition, we are developing new cleaning systems and sensors.

Compact plasma source with integrated high-voltage generator and extraction system with ozone filter for cleaning and pre-treatment.

2



Verification of the cleaning effect for triglycerides (cf. skin fat) by means of fluorescence studies following plasma treatment.

This includes the development of compact plasma sources that can be integrated into robot-guided and mobile self-sufficient systems, as well as systems for the in-situ production of ozonated water.

Outlook: Automated cleaning

Comprehensive knowledge of surface and material properties as well as different cleaning systems makes it possible to offer cleaning procedures adapted to the particular problem. In the future, sensors for the identification of material and soiling are to be integrated into the cleaning systems in order to develop automated cleaning procedures that are data-based and adapted to the material and the soiling, as well as new surfaces that can be optimally cleaned.

The project

The "MobDi" project is part of the "Fraunhofer vs. Corona" action program, which supports numerous other pandemic response initiatives.

Contact

Prof. Dr. Michael Thomas
Phone +49 531 2155 525
michael.thomas@ist.fraunhofer.de

Atmospheric pressure plasma treatment system for medium-sized 3D components (< 50 cm x 50 cm x 80 cm) with robot-guided plasma nozzle.

From research

Robot-guided plasma treatment of 3D surfaces

Robot-guided plasma treatments enable the structured modification of the surface chemistry of three-dimensional components. This makes it possible, for example, to control and improve the adhesion of coatings and bondings to surfaces. At the Fraunhofer IST, a corresponding treatment system has been successfully established and tested in order to enable the treatment of application-related components and the investigation of the influence of this treatment.

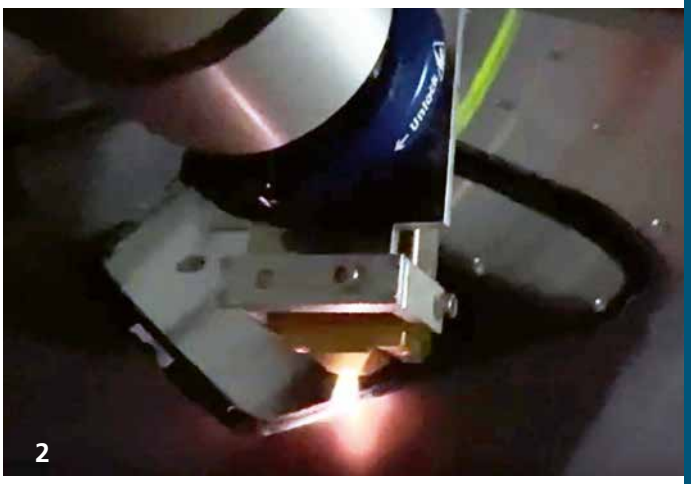
Possibilities with plasma treatment

With the aid of atmospheric-pressure plasmas, the surfaces of the most diverse materials – such as polymers, ceramics or metals – can be modified. Depending on the process gas, it is possible to etch, roughen, oxidize, reduce, functionalize or coat the surfaces. The surface properties and further processability of workpieces by means of bonding, painting or fusing can be significantly improved through plasma treatment. Contaminations can be removed, and wetting and adhesion can be enhanced. This is already being used intensively in technological applications, particularly on 2D surfaces such as polymer films and plates, and is the current state-of-the-art. A wide variety of plasma sources with varying functional principles and application possibilities are available for this purpose.

Robot-guided treatment with plasma jets

One interesting type of plasma source is the so-called plasma jet. These generate a jet of ionized and activated gas – plasma – which can treat a highly defined surface area. As a result of the activated gas, the chemical bonds necessary for surface modification can be broken. Plasma jets are particularly suitable for use in robot-guided systems, in order to carry out treatment on spatial components.

At the Fraunhofer IST, an atmospheric-pressure plasma treatment system for medium-sized 3D components (< 50 cm x 50 cm x 80 cm) with robot-guided plasma jet has been constructed. With this system, dielectric and electrically conductive materials can be treated with a nitrogenous plasma. The system features a housing with an extractor, with which harmful process gases can be removed.
The modification of the components is performed using a resolution of around 1 cm and a high power density of around 500 W/cm², with treatment speeds of up to 1 m/s. The improvement of, in particular, the adhesion of coatings and bondings on injection-molded polymer surfaces has already been successfully demonstrated with this method.



Plasma treatment of three-dimensional surfaces using a robot-guided system.

Outlook

In the future, in addition to cleaning and plasma activation, the Fraunhofer IST will also be increasingly investigating the layer deposition of e.g. adhesion-promoting layers on 3D surfaces. As well as improved automation ability of the processing, the focus will also be directed at the integration of the treatment into specific process chains.

Contact

Dr. rer. nat. Thomas Neubert
Phone +49 531 2155-667
thomas.neubert@ist.fraunhofer.de

Innovation driver and a key technology

Optics

Precise optical coatings and surfaces are required for a diverse range of applications in photonics, communications, semiconductor and microsystems technology, as well as in optical metrology. The improvement of the optical properties of components and the integration of new functions in optical systems are important research priorities in the field of optical technologies.

Mapping system for measurement of ellipsometry, reflection, transmission, flare and Raman spectroscopy.

Optical systems and applications for surface technology

Optical technologies rank among the most important growth and future industries of the German economy. In addition to the external appearance, the industrial focus is also on functionalization of optical components.

Coatings for both optical components and the associated system technology are being developed. With two EOSS® (enhanced optical sputtering system) sputtering facilities, production-ready systems are available for the manufacture of high-precision interference filters.

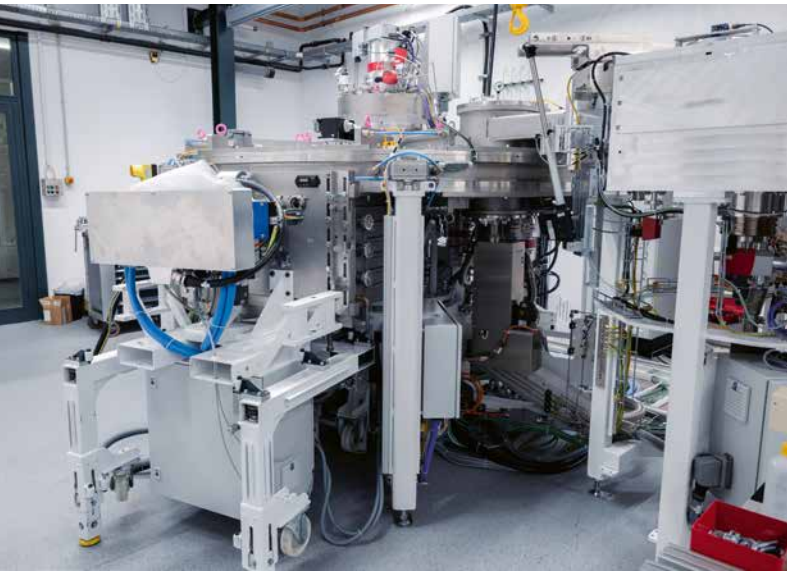
For the optimization of the processes and facilities, precise simulations and virtual coating runs are performed. We link these with optical measurement technology for process control and quality assurance: in-situ control with the MOCCA+® monitoring system, with an ex-situ mapping system for ellipsometry, photometry and Raman spectroscopy, or particle and defect analysis by means of FIB-SEM and confocal microscopy. New measurement systems are designed and constructed using tools such as Zemax, TracePro and COMSOL.

Optical coating on a substrate 200 mm in diameter and an optical density of 6. Top: reflection, bottom: transmission behavior.

#WeKnowSolutions

- Extensive and diversified expertise: Simulation and fabrication of complex interference filters
- Adaptation to your substrates (glass, plastics, planar, curved, subsequent cutting)
- Combination of optical layer systems with other functionalizations
- Development of new intelligent materials, e. g. switchable, transparent-conductive
- Design and development of optical measurement systems for in-situ and ex-situ applications

Top view of the turntable of the EOSS® sputter system from above.



Precision optics 2.0 – the second-generation EOSS® system for the deposition of optical-interference filter layers of the highest precision has been complementing the systems technology at the institute since 2022. Extremely low-defect coatings and highly complex layer designs with several hundred individual layers can be realized on both planar and curved surfaces by means of this system. The primary focus thereby is on extreme precision and uniformity of the coating. The process control is variable; coatings can, for example, be applied metallically, reactively or in meta-mode.

Contact

Dr. Michael Vergöhl
Phone +49 531 2155-640
michael.vergoehl@ist.fraunhofer.de

From research

Setup for high-precision wavefront measurement

Within the framework of the Euclid mission, ESA is investigating dark matter and the origin and expansion of the universe. The instrument thereby deployed has an imaging system for the visible, and a spectrometer for the near-infrared spectral range. The devices measure the light spectrum of distant stars, for which reason the optics are of a correspondingly high quality. The separation of the two channels is performed with the aid of a beam splitter. Physically determined – the separation is accomplished with the help of a dielectric multi-layer coating – the beam splitter shows specific wavefront errors depending on wavelength and angle of incidence. In order to be able to suitably characterize the component at all, a purpose-developed measurement setup is required, the development of which was undertaken by the Fraunhofer IST as an element of a design study.

The challenge

For optical systems with highly accurate imaging properties, the wavefront deformation – in addition to other imaging errors – plays a decisive role. The requirements for a setup such as that required for the ESA project are therefore exceptionally stringent: Firstly, the polarization-dependent measurement of the reflected wavefront error as well as the point spread function of the dichroite across an aperture of 117 mm must be facilitated. Secondly, the spectral range from 510 to 950 nm must be covered with a resolution of <0.4 nm. Furthermore, an adjustment possibility of the angle of incidence for 0°, as well as between 4° and 20° is desired.

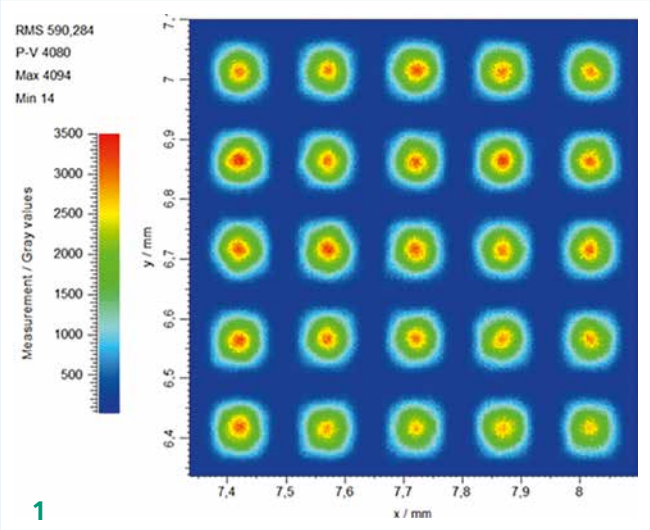
Measurement setup

In order to avoid chromatic aberrations, a design with mirror optics was selected. A tunable white-light laser serves as the light source, whilst the measurement of the actual wavefront is performed via a so-called Shack-Hartmann sensor. The two polarizers and the stage for setting the angle of incidence can be motorized. Solely for the measurement under 0° angle of incidence an additional beam splitter needs to be inserted.

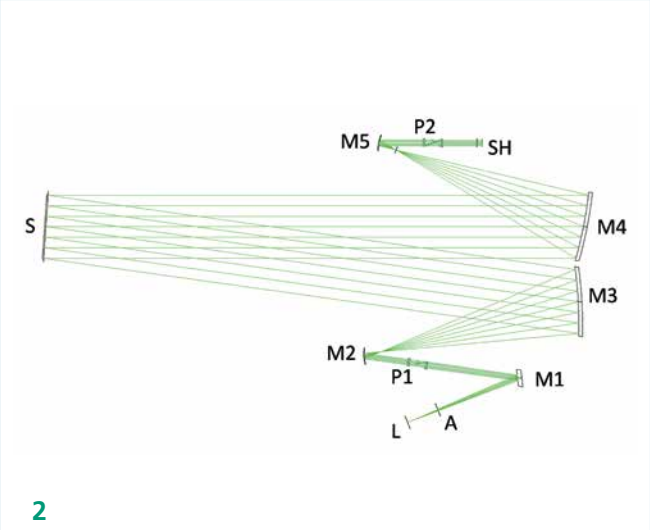
As the central component of the measurement setup, the Shack-Hartmann sensor was optimized in terms of focal length and the quantity and pitch of the micro-lenses. Thereby, the repeatability of the sensor was reduced from 2 nm to below 0.97 nm in the entire wavelength range. Furthermore, ghost images, noise and dynamic behavior of the sensor were investigated.

Measurement accuracy

Via Monte Carlo simulations, the cumulative wavefront error of the entire setup was ultimately estimated to be 45.3 nm (4-20°), or 66.5 nm (0°). As the wavefront error is only accessible as a relative magnitude from two wavefront measurements, a correspondingly accurate referencing is required. The actual accuracy of the measurement was determined to 1.71 nm RMS by means of an externally measured reference substrate, as well as through reconstruction and repeatability of the sensor.



Spot image measured on the Optocraft UHR3 Shack-Hartmann sensor at a wavelength of 1064 nm.



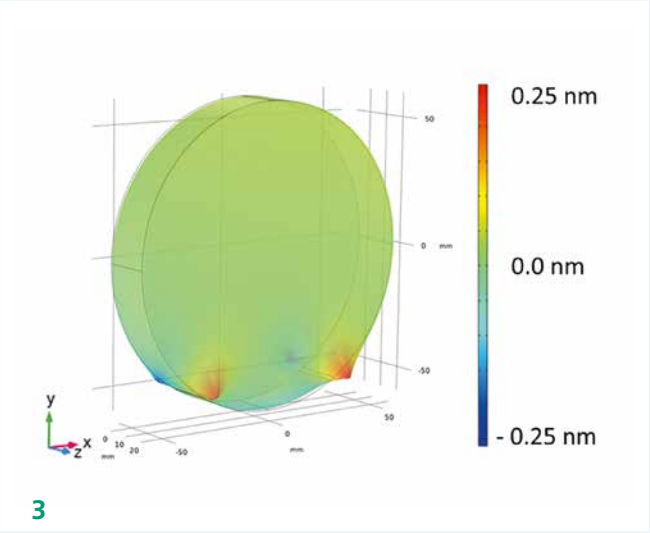
Beam path for the measurement of the wavefront error for an angle of incidence of 4°.

Outlook

The design study performed paves the way for high-precision wavefront measurements over broad spectral ranges that can be realized in similar setups. Competency in optical metrology and characterization as well as in optics design, including the use of ZEMAX, complement the expertise available at the Fraunhofer IST in the field of precision optical coatings.

The project

This research work was funded by ESA within the framework of project No. AO/1-10283/20/NL/PM and was conducted with the support of Asphericon (tolerance analysis) and Optocraft (measurements of Shack-Hartmann configurations).



Simulated surface deformation of the substrate in Z-direction due to the mounting.

Contact

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

Sustainable solutions for clean water, soil and air

Environmental technology, agricultural and food industry

The sector is facing a multitude of challenges related in particular to environmental protection, sustainability, food safety and the demands of a growing world population. The focus is therefore on the development of sustainable and environmentally-friendly solutions for meeting the needs of current and future generations.

Demonstrator of a mobile measuring gun with luminescent carrier foil.

Ensuring food security in the future requires innovative agricultural systems.

Innovative solutions for a better future

The environmental sector is being confronted with the growing challenges of climate change, environmental pollution and the consequential need for sustainable process chains and materials, as well as increasing digitalization. The growing world population and geopolitical instability furthermore present our current agricultural systems with complex tasks.

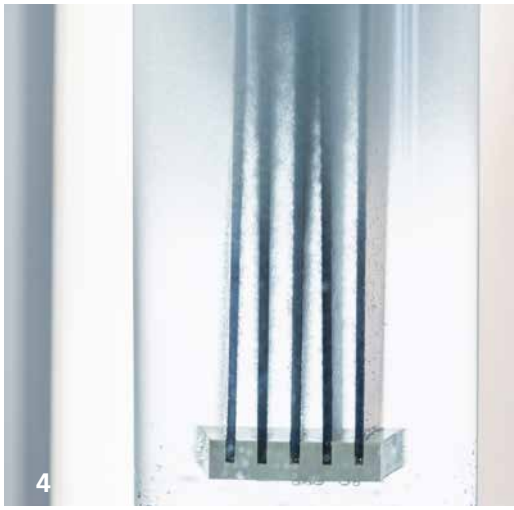
The safeguarding of reliable food security with simultaneous compliance with the necessary ecological standards and economic boundary conditions therefore urgently necessitates new solutions. The development of decentralized and resilient agricultural production systems for the safeguarding of food production can provide a significant contribution towards sustainable crisis management for the population.

Within the framework of the water, energy and food-security nexus, the Fraunhofer IST is developing, in interdisciplinary teams, sustainable processes and systems for water treatment and disinfection. We use diamond electrodes in order to generate highly effective oxidants in the water which can eliminate trace substances or prevent the formation of biofilms.

With diamond-like carbon coatings, we protect the surfaces of valves or heat exchangers in the chemical, pharmaceutical and food industries against fouling. Our electrochemical systems generate ozonated water, for example for cleaning soil and plant-cultivation tools and for pest control without additional chemicals (thereby increasing crop yields), for processing agricultural products or for disinfecting cultivation systems. In the field of plant cultivation, the Fraunhofer IST is also conducting research into novel solutions for the utilization of ozonated water. A research greenhouse on our campus featuring hydroponic cultivation systems, as well as the mobile backpack system OzoDis for on-demand nebulization of ozonated water, enable testing under real environmental conditions or directly in field trials. Furthermore, we utilize photocatalysts for water and air purification and evaluate their effectiveness in the laboratory as well as in the field.

Mobile system for the spraying of ozonated water for the surface disinfection of an asparagus-peeling machine.

Mobile ozon generator "DiaDis" for the production of ozonized water on the basis of diamond electrodes. The ozone, which is generated directly in water, can be used to reduce fouling on RO membranes and to prevent biofilms in ultrapure water or cooling systems. Alternatively, the system can be used to kill viruses, germs and pests, for example to disinfect surfaces or to improve plant growth.



Water purification by means of diamond electrodes.

#WeKnowSolutions

- Development of system solutions for water treatment and disinfection on the basis of stationary or mobile systems
- Reduction of cleaning and maintenance expenditure through antifouling coatings or by means of electrochemical sanitization
- Increase in crop yield through pest control or germ-reduced processing methods without the use of chemicals
- Certified evaluation of the performance capability of photocatalytically active products in accordance with DIN, CEN and ISO standards
- Testing of customer-specific developments in the real cultivation of plants in a laboratory greenhouse
- Utilization and adaptation of the mobile backpack system "OzoDis" for the demand-oriented nebulization of ozonated water
- Utilization and adaptation of the mobile disinfection unit on the basis of diamond electrodes "DiaDis" for the purification of waste water for agricultural irrigation
- Application of atmospheric-pressure plasma process for seed treatment

Contact

Dipl.-Ing. (FH) Frank Neumann
Phone +49 531 2155-658
frank.neumann@ist.fraunhofer.de

Dr. Guido Hora
Phone +49 531 2155-373
guido.hora@ist.fraunhofer.de

From research

Research for the crop production of the future

Safeguarding the worldwide food supply is becoming increasingly challenging as a result of progressive climate change and the intensive exploitation of ecosystems: Water scarcity is increasing even in our latitudes, diverse contaminants hinder the reuse of water, energy prices are rising, and armed conflicts are impeding cultivation and export. This necessitates new solutions for producers in order to enhance their productivity whilst also minimizing the consumption of energy and water. Water suppliers and water users require solutions in order to reduce pollutants and avoid the utilization of chemicals.

Crop production with highly productive cultivation systems

For the greatest possible control and optimization of cultivation conditions, vegetable growers are increasingly using greenhouses and hydroponic cultivation systems. These highly engineered systems present a wide range of challenges for which the Fraunhofer IST is developing solutions – with the aid of coating and surface technology as well as digitization. A greenhouse, newly built on the campus in Braunschweig, thereby serves as both a research laboratory and a demonstrator for customers and partners (see Figure 1) in order to research and further develop sustainable agricultural systems.

The hydroponic cultivation systems installed in the greenhouse can be used to research aspects of plant production as well as to address R&D topics in the areas of irrigation and nutrient solutions.

Disinfection and pest control without the addition of chemicals

Using diamond-coated electrodes, ozone dissolved in water can be produced in a very energy-efficient manner. This enables process water systems and surfaces to be disinfected without having to add chemicals. The Fraunhofer IST has developed two demonstrator systems: In the mobile DiaDis unit (see Figure 2), 100 liters of ozonated water can be provided with up to 10 mg/m³ ozone, which, amongst other things, can be applied in plant cultivation to treat soils and to combat nematodes. With the portable spray unit (see Figure 3), surfaces can be disinfected and pests on plants can be combated.

[1]Kanfra, Xorla ; Elhady, Ahmed ; Thiem, Hendrik ; Pleger, Sven ; Höfer, Markus ; Heuer, Holger: Ozonated water electrolytically generated by diamond-coated electrodes controlled phytonematodes in replanted soil. In: Journal of Plant Diseases and Protection (2021), Nr. 128, S. 1657–1665

Research greenhouse at the Fraunhofer IST.

Control of pests on plants with ozonated water.

Outlook

The newly built greenhouse will be continuously expanded and equipped with additional production technology. Sensors and controls will enable digitization of plant production for monitoring, automation and process control. In the greenhouse, customers and partners will be able to test developments under real growing conditions.

The DiaDis system and the portable spray unit are available for trial use at customers' premises; the ozonated water can be used to disinfect process water systems or surfaces and, based on the results, adapted systems can be developed to meet specific requirements.

Contact

Dr.-Ing. Jan Gäbler
Phone +49 531 2155-625
jan.gaebler@ist.fraunhofer.de

The Fraunhofer IST in networks

Headquarters of the Fraunhofer-Gesellschaft.

The Fraunhofer-Gesellschaft at a glance

The Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. It is a trailblazer and trendsetter in innovative developments and research excellence. The Fraunhofer-Gesellschaft supports research and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

The Fraunhofer-Gesellschaft's interdisciplinary research teams turn original ideas into innovations together with contracting industry and public sector partners, coordinate and complete essential key research policy projects and strengthen the German and European economy with ethical value creation. International collaborative partnerships with outstanding research partners and businesses all over the world provide for direct dialogue with the most prominent scientific communities and most dominant economic regions.

Founded in 1949, the organization currently operates 76 institutes and research facilities in Germany. The annual research volume of around €3.0 billion is expended by our workforce of currently around 30,800 employees, most of whom are trained in science or engineering. Fraunhofer generates €2.6 billion of this from contract research. Industry contracts and publicly funded research projects account for around two thirds of that. The federal and state governments contribute around another third as base funding, enabling institutes to develop solutions now to problems that will become crucial to industry and society in the near future.

The impact of applied research goes far beyond its direct benefits to clients: Fraunhofer institutes enhance businesses' performance, improve social acceptance of advanced technology and educate and train the urgently needed next generation of research scientists and engineers.

For us, as a scientific organization, highly motivated employees who conduct cutting-edge research constitute the most important success factor. Fraunhofer consequently provides opportunities for independent, creative and goal-driven work and thus for professional and personal development, qualifying individuals for challenging positions at our institutes, at higher education institutions, in industry and in society. Practical training and early contacts with clients open outstanding opportunities for students to find jobs and experience growth in business and industry.The prestigious nonprofit Fraunhofer-Gesellschaft's namesake is Munich scholar Joseph von Fraunhofer (1787–1826). He enjoyed equal success as a researcher, inventor and entrepreneur.


Main locations
Other locations
Itzehoe
Rostock
Lübeck
Stade
Bremerhaven
Hamburg
Oldenburg
Bremen
Wolfsburg
Hannover
Braunschweig
Berlin
Potsdam
Teltow
Wildau
Magdeburg
Lemgo
Goslar
Münster
Paderborn
Gelsenkirchen
Hamm
Oberhausen
Soest
Göttingen
Halle
Cottbus
Schwarz-
heide
Schkopau
Dortmund
Bochum
Leipzig
Duisburg
Kassel
Leuna
Schmallenberg
Willich
Dresden
Zittau
Sankt Augustin
Jena
Freiberg
Aachen
Erfurt
Bonn
Hermsdorf
Euskirchen
Gießen
Chemnitz
Wachtberg
Ilmenau
Zwickau
Remagen
Frankfurt
Hanau
Alzenau
Münchberg
Mainz
Aschaffenburg
Bayreuth
Bamberg
Darmstadt
Würzburg
Waischenfeld
Kaiserslautern
Erlangen
Sulzbach
Wertheim
St. Ingbert
Fürth
Sulzbach-Rosenberg
Mannheim
Nürnberg
Saarbrücken
Karlsruhe
Pfinztal
Regensburg
Straubing
Ettlingen
Esslingen
Stuttgart
Deggendorf
Passau
Augsburg
Freising
Garching
Freiburg
München
Weßling
Rosenheim
Kandern
Penzberg
Holzkirchen
Prien
Efringen-
Kirchen

Synergies through networking – Networks within the Fraunhofer-Gesellschaft

Within the framework of its research and development activities the Fraunhofer IST is an integral element of various internal and external networks which are active with diverse focal points in the field of tension between industry, science and politics.

Within the Fraunhofer-Gesellschaft, the Institute has been contributing its expertise in the Fraunhofer Group for Production, which consolidates the specialist knowledge of the Fraunhofer-Gesellschaft for the "production of the future". Furthermore, the Fraunhofer IST participates as a guest member in the Fraunhofer Group for Light & Surfaces, as well as in various alliances, business sectors, research and competence fields, and networks. The objective is to offer customers and partners optimum solutions for their tasks, including cross-technological options. In addition, the Fraunhofer IST is actively involved in the Fraunhofer Centers for Energy Storage and Systems ZESS and for Circular Economy for Mobility CCEM in Wolfsburg. In the High-Performance Center Medical and Pharmaceutical Engineering, which was launched in March 2021, the institute is involved in the development of a platform for research and innovation transfer in patient care.

Fraunhofer Group
Production

Fraunhofer Group
Light & Surfaces

Research Field
Lightweight Design

Business Area
Adaptronics

Business Area
Cleaning

Fraunhofer Alliance
SysWasser

Fraunhofer Cluster of Excellence
Cognitive Internet Technologies

High-Performance Center
Medical and Pharmaceutical

Fraunhofer Alliance
Battery

Fraunhofer
POLO®

Fraunhofer Network
Sustainability

Fraunhofer Network
Hydrogen

Fraunhofer Alliance
autoMOBILproduction

Fraunhofer Network
Simulation

Fraunhofer Competence Field
Additive Manufacturing

Fraunhofer Center
Circular Economy for Mobility CCEM

Fraunhofer
AVIATION & SPACE

Fraunhofer Center for
Energy Storage and Systems

Regional and nationwide networking

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.

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 Center Circular Economy for Mobility

The research campus Open Hybrid LabFactory e.V. (OHLF) is considered one of the leading addresses in Germany for the research and development of solutions for the sustainable design of future industrial vehicle production in the sense of a circular economy. Here, the Fraunhofer CCEM and the TU Braunschweig are working together on the economically and ecologically sustainable development and evaluation of new materials, production techniques and digital methods, which are an indispensable prerequisite for the implementation of future circular systems. In the Fraunhofer CCEM, the Fraunhofer IST, in collaboration with the Fraunhofer institutes IFAM, IWU and WKI, is conducting research into methods for automated dismantling, cleaning, re-manufacturing, re-use and sustainable surface processes along a circular process chain as well as the near-series testing of these technologies.

Fraunhofer Center for Energy Storage and Systems ZESS

As a joint research and transfer platform, the Center is working on the development of system solutions for batteries and fuel cells in the field of electromobility as well as for stationary storage systems as components of the energy revolution. With the objective of developing mobile and stationary storage technologies to market maturity, the Fraunhofer IST, together with the Fraunhofer Institutes IKTS and IFAM as well as the Battery LabFactory Braunschweig of the TU Braunschweig, is pooling its technical expertise and researching the further development of the technologies into prototype-capable solutions and systems.

Wasserstoff Campus Salzgitter (Hydrogen campus)

At the Wasserstoff Campus Salzgitter (Hydrogen campus) the Fraunhofer IST is working in cooperation with the City of Salzgitter, Salzgitter AG, MAN Energy Solutions, Bosch, Alstom, WEVG and regional companies to develop CO_2-neutral solutions for industrial use with regional hydrogen expertise.

Cooperations with the TU Braunschweig

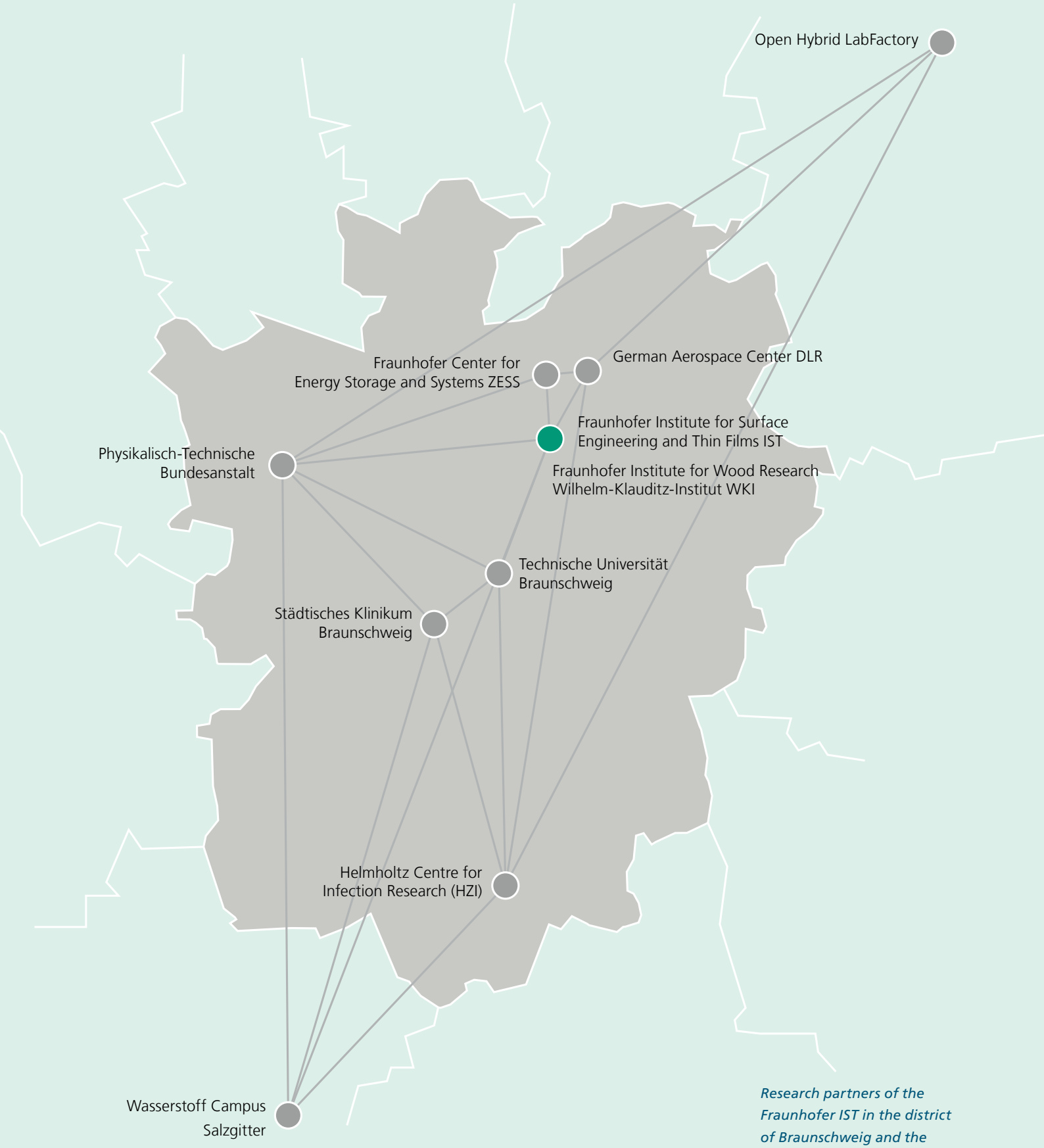
- Battery LabFactory Braunschweig BLB
- Automotive Research Centre Niedersachsen NFF
- Aeronautics Research Centre Niedersachsen NFL
- Center of Pharmaceutical Engineering PVZ
- Open Hybrid LabFactory e.V.

Sites Göttingen and Dortmund

The department Application Center of the Fraunhofer IST in Göttingen focusses on the research on new, application-oriented fields in the area of plasma technologies under atmospheric pressure and the development of tailor-made plasma in cooperation with the HAWK University of Applied Sciences and Art. At the Dortmunder OberflächenCentrum DOC, ThyssenKrupp Steel Europe, together with its on-site partners Fraunhofer IST and Fraunhofer IWS, develops industry-ready solutions in the field of surface engineering for flat steel products.and wear protection solutions for hot-forming production.

Strategic partnership with the Kompetenzzentrum Tribologie in Mannheim

In cooperation with the Hochschule Mannheim – University of Applied Sciences the Fraunhofer IST is working on the expansion of their joint research activities in the field of tribology and surfaces.



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

The Competence Network Industrial Plasma Surface Technology e. V. – INPLAS

The Competence Network INPLAS e.V. pursues the goal of further publicizing the potential of plasma technology and supporting, promoting, and moderating developments in the numerous fields of application in their respective complexity. The network is accredited by the German Federal Ministry for Economic Affairs and Climate Action in the "go-cluster" program and has been awarded the Silver Label for Cluster Management Excellence. INPLAS currently has 55 members from industry and science with around 200 active persons. 75 percent of the members come from industry.

General meeting in the event and start-up location "LOKSCHUPPEN Marburg"

In the past year, INPLAS again organized a variety of activities around surface technology topics. Members and partners were particularly happy that face-to-face meetings took place again, where networking was possible in addition to the technical presentations. We would like to thank all members for their commitment and active support. Some highlights of the activities, projects and events in 2022 are presented below:

12th International Conference on Fundamentals and Industrial Applications of HIPIMS 2023

INPLAS participated and presented itself as co-organizer at the 12th edition of the International Conference on Fundamentals and Industrial Applications of HIPIMS in June 2022, which was organized by the University of Sheffield in cooperation with other partners. After the "Corona break", the conference took place again in Sheffield with around 100 participants. The overall topic, which was also discussed intensively in a panel discussion with the auditorium, was "Surface Engineering for net zero". The technological sessions included various keynote presentations from the perspectives of industry, research, and project management.

The technical presentations dealt with, among other things, the targeted modification of the layer structure by varying the ion energy, CO_2 reduction by vacuum coating, aspects of digitalization in surface technology and especially HIPIMS, the topic of optoelectronics, hydrogen technologies – in particular bipolar plates, active process control of reactive HIPIMS processes, and the question of whether there is an upper limit to the pulse current in HIPIMS processes.

INPLAS joint booth at the 18th International Conference on Plasma Surface Engineering (PSE) 2022

From September 12 – 15, 2022, the 18th PSE took place in Erfurt with nearly 500 participants and 62 industrial exhibitors. The following partners presented themselves in the industrial exhibition at the INPLAS joint booth: CCR Technology GmbH, Comet AG, Fraunhofer IST, Nadir S.r.l., Softal Corona & Plasma GmbH, Leibniz Institute for Plasma Research and Technology e.V. (INP) and the Competence Network Industrial Plasma Surface Technology e.V. (INPLAS) itself.

INPLAS working groups

The 7th meeting of the "Plasma4Life" WG in March 2022 with the management team Prof. Dr. Peter Awakowicz, Dr. Kristina Lachmann and Prof. Dr. Wolfgang Viöl focused on the field of hygiene in clinics and public spaces. In 9 presentations, the KARMIN project – the patient room of the future – automated UV-C disinfection of surfaces with the aid of robots, material-friendly cleaning tools for mobile applications, and technologies for room air purification were presented, among others.

INPLAS member overview (status: December 2022). 2

The "Tool Coatings" WG headed by Hanno Paschke, Fraunhofer IST, also met twice in virtual form. At the two meetings in March and December 2022, the participants discussed ecological and function-optimized pre-treatment chains for the plasma coating of complex-shaped tools, the recycling of cutting tools, additive process chains, and issues in the field of CVD diamond and coated carbide tools.

The "Novel Plasma Sources and Processes" WG with the leading team Dr. Anke Hellmich, Applied Materials GmbH & Co. KG, Matthias Nestler, scia systems GmbH, and Dr. Ulf Seyfert, Von Ardenne GmbH, devoted itself to – among other topics – the measurement and avoidance of particles, non-contact in-situ temperature measurement and plasma-assisted local atomic layer deposition (ALD) during meetings at Robert Bosch Manufacturing Solutions GmbH in June and with hosts Schneider GmbH & Co. KG and W&L Coating Systems GmbH, in Marburg in November.

In May 2022, at the 22nd meeting of the "Combined Surface Technology" joint committee, chaired by Prof. Dr. Petra Uhlmann, Leibniz Institute of Polymer Research, the participants addressed a range of topics, including the topic of circular economy in plastics electroplating, on site at the host BIA Kunststoff und Galvanotechnik GmbH & Co. KG and online.

The INPLAS joint project "Plasma Diagnostics for Plasma Processes 4.0 - PDP 4.0", also initiated as a result of the activities of the focus group "Digitalization & AI", started on October 1, 2022. The eight partners met for the kick-off meeting, also in October, in a hybrid format at the Fraunhofer IST in Braunschweig and online.

17th INPLAS General Meeting

The 17th INPLAS General Meeting was held at the event and start-up center LOKSCHUPPEN Marburg with Schneider GmbH & Co. KG and W&L Coating Systems GmbH as hosts. Key agenda items included activities during the reporting period, planned events, and a brainstorming session to help identify strategic topics in the areas of sustainable production, agriculture, hygiene, and digitalization for future networking. The location offered an exciting insight into agile forms of work or new work topics and showed opportunities for start-ups to use synergies from different work disciplines. Many companies were certainly also able to take away ideas for the transformation of working worlds during the event.

Contact

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

Dr. Jochen Borris
Projektleiter
Phone +49 531 2155-666
jochen.borris@inplas.de

www.inplas.de

Memberships

AiF InnovatorsNet
www.aif-ftk-gmbh.de

Arbeitgeberverband Region Braunschweig e. V.
https://agv-bs.de/

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

Battery LabFactory Braunschweig BLB
https://www.tu-braunschweig.de/blb

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

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

DGM Deutsche Gesellschaft für Materialkunde e. V.
https://dgm.de/de/home

Deutsches Flachdisplay-Forum e. V.
www.displayforum.de

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

Deutsche Vakuum-Gesellschaft DVG e. V.
www.physik.uni-kl.de/dvg/index.php/die-dvg

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

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

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

European Institute of Innovation and Technology for Raw Materials (EIT)
https://eitrawmaterials.eu/

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

European Lithium Institute eLi
www.lithium-institute.eu

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

FGW Forschungsgemeinschaft Werkzeuge und Werkstoffe e. V.
www.fgw.de

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

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

Fraunhofer-Allianz autoMOBILproduktion
www.automobil.fraunhofer.de

Fraunhofer-Allianz Batterien
www.batterien.fraunhofer.de

Fraunhofer AVIATION & SPACE
https://www.aviation-space.fraunhofer.de/

Fraunhofer-Allianz SysWasser
www.syswasser.de

Fraunhofer Cluster of Excellence Cognitive Internet Technologies
www.cit.fraunhofer.de

Fraunhofer Forschungsfeld Leichtbau
www.leichtbau.fraunhofer.de

Fraunhofer Geschäftsbereich Adaptronik
www.adaptronik.fraunhofer.de

Geschäftsbereich Reinigung
www.allianz-reinigungstechnik.de

Fraunhofer Kompetenzfeld Additive Fertigung
www.additiv.fraunhofer.de

Fraunhofer-Netzwerk Nachhaltigkeit
www.fraunhofer.de/de/ueber-fraunhofer/corporateresponsibility/governance/nachhaltigkeit/fraunhofer-netzwerknachhaltigkeit.html

Fraunhofer-Netzwerk Simulation
www.simulation.fraunhofer.de

Fraunhofer-Netzwerk Wasserstoff
www.fraunhofer.de/de/forschung/aktuelles-aus-der-forschung/wasserstoff.html

Fraunhofer POLO® – Polymere Oberflächen
www.polo.fraunhofer.de

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

Fraunhofer-Verbund Produktion
www.produktion.fraunhofer.de

German Water Partnership
www.germanwaterpartnership.de

GFT Gesellschaft für Tribologie e.V.
https://www.gft-ev.de/de/home_de/

Göttinger Research Council
www.uni-goettingen.de

Haus der Wissenschaft Braunschweig GmbH
www.hausderwissenschaft.org

Innovationsnetzwerk Niedersachsen
www.innovationsnetzwerk-niedersachsen.de

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

International Ozone Association
https://www.ioa-ea3g.org/

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

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

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

Leistungszentrum Medizin- und Pharmatechnologie
www.lz-mpt.fraunhofer.de/

Marketing Club Braunschweig e.V.
https://www.marketingclub-bs.de/

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

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

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

Optence e. V.
www.optence.de

PhotonicNet GmbH – Kompetenznetz Optische Technologien
www.photonicnet.de

Plasma Germany
www.plasmagermany.org

R2R NET
https://r2r-net.eu/

Spectaris – Deutscher Industrieverband für Optik, Photonik, Analysen- und Medizintechnik e. V.
www.spectaris.de

SVC Society Vacuum Coaters
https://www.svc.org/

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

Zentrum für Pharmaverfahrenstechnik PVZ
www.tu-braunschweig.de/pvz

ZIM-Netzwerk AgarCycle
https://www.hs-osnabrueck.de/zim-agrarcycle/

Publications

Barasinski, M., Schilde, C., Melzig, S., Hübner, M., Garnweitner, G., & Zellmer, S. (2022). Micromechanical properties of spray-dried core-shell silica aggregates along with drug release tests (null6). https://doi.org/10.1016/j.jciso.2022.100052

Baron, S., Tounsi, T., Gäbler, J., Mahlfeld, G., Stein, C., Höfer, M., Sittinger, V., Hoffmeister, H.-W., Herrmann, C., & Dröder, K. (2022). Diamond coatings for advanced cutting tools in honing and grinding (Vol. 108). https://doi.org/10.1016/j.procir.2022.03.093

Brückner, T., Paschke, H., Thewes, A., Reinders, P. M., Kipp, C., Sternemann, C., & Paulus, M. (2022). Low-temperature plasma nitriding to enhance tribocorrosive resistance of corrosion-resistant steel. https://publica.fraunhofer.de/handle/publica/439509

Bruns, S., Henning, P., Melzig, T., Terhürne, J. & Vergöhl, M. (2022). Improving optical monitoring accuracy by including systematic transmittance deviations (Vol. 62, Issue 7). https://doi.org/10.1364/AO.475076

Duckstein, R., Gerdes, H., & Seemann, T. (2022). Digitale Werkzeuge - nachhaltig & modular (Vol. 62, Issue S2). https://doi.org/10.1007/s35144-022-1589-z

Dültgen, P., Pelshenke, C., Peddinghaus, J., Siegmund, M., & Paschke, H. (2022). Belastungsangepasste strukturierte Diffusionsbehandlungen zur Verbesserung des thermomechanischen Rissverhaltens von Schmiedegesenken. https://publica.fraunhofer.de/handle/publica/439537

Gäbler, J., Bethke, R., Hatic, D., Rauhut, M., Weibel, T., Cheng, X., Eder, M., Eder, S., Bagcivan, N., & Bastürk, S. (2022). Rockwell-Schichthaftungstest - Der maschinelle Blick. https://doi.org/10.1007/s35144-022-1513-6

Gebken, N., Horbelt, J., Kleine-Wechelmann, S., Ort, T., Puls, S., Schandar, M., Traube, A., Biermann, F., Brandstätter, T. C., Gräfe, S., Herbst, L., König, N., Schmitt, R., Ackermann, H., Diessel, E., Lengen, R. H. van, Schmidt, A., Braun, D., Hunger, S., … Tradler, T. (2022). Skalierbare Herstellung von ATMPs. https://doi.org/10.24406/ipa-n-648009

Hagen, J. S., Arafat, R., Abraham, T. G., & Herrmann, C. (2022). Function oriented biological transformation of a lubrication process system (Vol. 110). https://doi.org/10.1016/j.procir.2022.06.007

He, W., Henne, A., Lauterbach, M., Geißmar, E., Nikolka, F., Kho, C., Heinz, A., Dostert, C., Grusdat, M., Cordes, T., Härm, J., Goldmann, O., Ewen, A., Verschueren, C., Blay-Cadanet, J., Geffers, R., Garritsen, H. S. P., Kneiling, M., Holm, C. K., … Hiller, K. (2022). Mesaconate is synthesized from itaconate and exerts immunomodulatory effects in macrophages (Vol. 4, Issue 5). https://doi.org/10.1038/s42255-022-00565-1

Henning, P., Jupé, M., Bruns, S., Melzig, T., Steinecke, M., Wienke, A. & Vergöhl, M. (2022). Manufacturing of Si-based hybrid metamaterials for increasing the refractive index in interference coatings. https://doi.org/10.1364/OIC.2022.MD.1

Kipp, C., Reinders, P., Brückner, T., Paschke, H., Thewes, A., Sternemann, C., & Paulus, M. (2022). Influence of increased temperature on the compound layer of nitrided steels. https://publica.fraunhofer.de/handle/publica/439519

Köhn, C., Arafat, R., Jean-Fulcrand, A., Abraham, T. G., Herrmann, C., & Garnweitner, G. (2022). Surface interactions of SiO2-nanofluids with 100Cr6-steel during machining (Vol. 108). https://doi.org/10.1016/j.procir.2022.03.008

Leiden, A., Thiede, S., & Herrmann, C. (2022). Synergetic modelling of energy and resource efficiency as well as occupational safety and health risks of plating process chains. https://doi.org/10.1007/s40684-021-00402-y

Menzler, M., Ganskow, C. S. G., Ruschig, M., Moustafa, E., Sittinger, V., Lachmann, K., Wenzel, E. V., Russo, G., Klahn, P., & Gäbler, J. (2022). Testing of diamond electrodes as biosensor for antibody-based detection of immunoglobulin protein with electrochemical impedance spectroscopy (Vol. 8, Issue 4). https://doi.org/10.3390/c8040074

Mrotzek, J., & Viöl, W. (2022). Spectroscopic characterization of an atmospheric pressure plasma jet used for cold plasma spraying (Vol. 12, Issue 13). https://doi.org/10.3390/app12136814

Paschke, H., Weber, M., Brunotte, K., Rothgänger, M., Petersen, T., Siegmund, M., & Peddinghaus, J. (2022). Load-adapted surface modifications to increase lifetime of forging dies (Vol. 926). https://doi.org/10.4028/p-5l24m7

Pflug, A., Bruns, S., Zickenrott, T., Britze, C. & Vergöhl, M. (2022). A digital twin for PVD deposition of tailored coatings on 3D substrates. https://doi.org/10.1364/OIC.2022.TC.8

Reibert, D., Tzanetos, F., Sydow, S., Bialuch, I., Lee, T. H., Abraham, T. G., Zontar, D., & Brecher, C. (2022). Integration of bio-based insulation materials as a contribution to the biological transformation of production technology (Vol. 110). https://doi.org/10.1016/j.procir.2022.06.055

Richter, M., Dittrich, R., Zindel, A., Nousch, L., Lehmann, M., Franke, M., Eißmann, N., Hutsch, T., Cerdas Marin, J. F., Zellmer, S., & Herold, D. (2022). Development and environmental assessment of a phase change material based thermal management system for Na/NiCl2 batteries (Vol. 8, Issue 11). https://doi.org/10.3390/batteries8110197

Rogall, C., Mennenga, M., Herrmann, C., & Thiede, S. (2022). Systematic development of sustainability-oriented cyber-physical production systems (Vol. 14, Issue 4). https://doi.org/10.3390/su14042080

Rosic, M., Leiden, A., Abraham, T. G., & Herrmann, C. (2022). Data mining approach for device detection using power signatures and manufacturing execution system data (Vol. 107). https://doi.org/10.1016/j.procir.2022.05.106

Roth, T., & Lachmann, K. (2022). Cold plasma. Contactless disinfection of surfaces. https://publica.fraunhofer.de/handle/publica/417952

Schnurrer, S., Beuscher, J. P., & Scheffler, F. (2022). Kurzfristige Lösungen für grünen Wasserstoff in Salzgitter. https://doi.org/10.24406/publica-1152

Sittinger, V., Schulze, P., Meßmer, C. A., Pflug, A., & Goldschmidt, J. C. (2022a). Complex refractive indices of Spiro-TTB and C60 for optical analysis of perovskite silicon tandem solar cells (Vol. 30, Issue 21). https://doi.org/10.1364/OE.458953

Sittinger, V., King, H., Kabakli Ö. S., Schulze, P. and Goldschmidt, J. C. (2022). Optimization and characterization of indium zinc oxide TCOs for perovskite-silicon tandem solar cell applications. https://doi.org/10.4229/WCPEC-82022-2AV.3.16

Stortz, F., Went, J., Koschikowski, J., Nasimul, Md., Maruf, I., Schäfer, L., Neumann, F., Lotz, B., Beckett, M. & Hamann, M. (2022). Smart mobile vaccination pickup for sustainable improvement of medical care and smart pandemic control in Southern Africa.

Thewes, A., Bröcker, L., George, E. T. K., Bräuer, G., Paulus, M., Sternemann, C., Paschke, H., Brückner, T., Lechner, S., & Müller, S. (2022a). Ti-Si-B-C-N plasma enhanced chemical vapor deposition nanocomposite coatings for high temperature applications (Vol. 760). https://doi.org/10.1016/j.tsf.2022.139507

Thewes, A., Kipp, C., Reinders, P. M., Brückner, T., Sternemann, C., & Paulus, M. (2022b). Oxidation resistance of PECVD Ti-Si-C-N nanocomposite coatings. https://publica.fraunhofer.de/handle/publica/439406

Wang, X., Mayrhofer, L., Keunecke, M., Estrade, S., Lopez-Conesa, L., Moseler, M., Waag, A., Schäfer, L., Shi, W., Xiangjian, M., Chu, J., Fan, Z., & Shen, H. (2022). Low-energy hydrogen ions enable efficient room-temperature and rapid plasma hydrogenation of TiO2 Nanorods for Enhanced Photoelectrochemical Activity (Vol. 18, Issue 46). https://doi.org/10.1002/smll.202204136

Weber, M., Vorobev, D., & Viöl, W. (2022). Microwave plasma-enhanced parylene-metal multilayer design from metal salts (Vol. 12, Issue 15). https://doi.org/10.3390/nano12152540

Wiese, M., Rogall, C., Henningsen, N., Herrmann, C., & Thiede, S. (2022). Environmental and technical evaluation of additive manufacturing (Vol. 105). https://doi.org/10.1016/j.procir.2022.02.073

Dissertation

King, H. J. (2022). Low-temperature silicon deposition by means of hot-wire chemical vapour deposition. Fraunhofer Verlag. https://publica.fraunhofer.de/handle/publica/418470

Patent granted

Eichler, M.; Nagel, K.; Thomas, M.: Vorrichtung zum leichten Entfernen von parasitären Beschichtungen bei der Abscheidung mit der Dielektrischer Barrierenentladung. DE10 2007006786 A1

Conference contributions

Bandorf, R. (2022): Active control of reactive HIPIMS processes using spectroscopic and electric parameters. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Bandorf, R. (2022): Antimicrobial effectivity of Me-DLC coatings prepared by HIPIMS. 65th Annual SVC Technical Conference, 2.5.-5.5.2022 – Talk.

Baron, S., Tounsi, T., Gäbler, J., Mahlfeld, G., Stein, C., Höfer, M., Sittinger, V., Hoffmeister, H.-W., Herrmann, C., Dröder, K. (2022): Diamond coatings for advanced cutting tools in honing and grinding. 6th CIRP Conference on Surface Integrity, 8.6.-10.6.2022 – Talk.

Brokmann, J., Dilger, N., Kaminski, M., Hesselbach, J., Zellmer, S., Kwade, A. (2022): Establishment and application of lithium metal anodes on novel metal-polymer composite current collectors to increase safety and energy density. International Battery Production Conference IBPC, 7.11.-9.11.2022 – Poster.

Brückner, T. (2022): Investigation on low-temperature plasma nitriding under industry-related treatment conditions for rolling bearing components. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Poster.

Brueckner, T.; Paschke, H.; Kaestner, P.; Hahn, I.; Siebert, S.; Weber, S. (2022): Transfer of economical low temperature nitriding processes to industrial scale treatments POSEIDON (II). 63. GfT-Tagung, 26.09.-28.09.2022 – Talk.

Castro, M. P.; Montiel, M. A.; Mena, I. F.; Rodrigo, M. A.; Gäbler, J.; Höfer, M.; Armgardt, M.; Schäfer, L. (2022): Electrochemical production of persulfate with boron-doped diamond electrodes. International Conference on Ozone and Advance Oxidation EA3G2022. Toulouse, 28.11.-30.11.2022 – Poster.

Gäbler, J., Glaß, S., Filiz, V., Neumann, F. (2022): Resistance of polymeric ultrafiltration membranes exposed to ozone produced by diamond electrodes. International Conference on Ozone and Advance Oxidation EA3G2022. Toulouse, 28.11.-30.11.2022 – Poster.

Gerdes, H. (2022): A data centric approach to handle processes in surface technology. 65th Annual SVC Technical Conference, 2.5.-5.5.2022 – Talk.

Gerdes, H. (2022): Applied research in surface technology. ISA-CApp - The International Symposium on Advanced Coatings and Applications, Benguerir, 14.11.-16.11.2022 – Talk.

Gerdes, H. (2022): Approach to digitizing your sputtering system. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Gerdes, H. (2022): Digitalization and data management for Vacuum processes. 12. International Conference on Fundamentals and Industrial Applications of HIPIMS, 15.6.-17.6.2022 – Talk.

Graumann, T., Pleger, S., Jacobs, C., Beyen, C., Sittinger, V. (2022): Photocatalytic Degradation of Harmful Pollutants to Improve Indoor and Outdoor Air Quality. 22nd International Conference on Atomic Layer Deposition ALD, 26.6.-29.6.2022 – Poster.

Grube, M., Hofer, M., Burmeister, C. F., Michalowski, P., Zellmer, S., Kwade, A. (2022): Upscaling of solvent-free synthesis of sulfide-based solid electrolytes and demonstration of a continuous production process. International Battery Production Conference IBPC, 7.11.-9.11.2022 – Talk.

Herrmann, C. (2022): LCA-based surface engineering. Quo Vadis Surface Engineering Symposia, 1.6.-2.6.2022 – Talk.

Hora, G., Henniger, M. (2022): Horizon Europe / Improving success chances to receive EU funding. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Kunkel, L., Zellmer, S., Kwade, A. (2022): Developing robust and scalable recycling routes for cathode active materials in lithium-ion batteries. International Battery Production Conference IBPC, 7.11.-9.11.2022 – Poster.

Mejauschek, M. (2022): Gasboring of tool steels and its tribological evaluation. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Poster.

Mejauschek, M., Paschke, H., Weber, M., Herrmann, C., Kaestner, P., Vogtmann, J. (2022). New surface boriding technologies. International Ceramics Congress, 20.6.-29.6.2022. https://publica.fraunhofer.de/handle/publica/418610

Neubert, T., Lachmann, K., Thomas, T. (2022): Atmospheric pressure microplasma sources for additive manufacturing. 18th International Conference on Plasma Surface Engineering, Erfurt, 12. 9.-15.9.2022 – Talk.

Omelan, M. (2022): Adhesion control of sustainable materials by atmospheric pressure plasma process. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Omelan, M. (2022): Bio-based thin film coatings using sustainable materials. 5th CIRP Biomanufacturing Conference, 22.6.-24.6.2022 – Talk.

Omelan, M. (2022): Klebstofffreies Fügen von homogenen und heterogenen Materialverbunden via AD-Plasma. 42. Workshop AK-ADP, 09.11.-10.11.2022 – Talk.

Paschke, H. (2022): Adhesion reducing surface modifications on aluminum processing tools. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Poster.

Paschke, H.; Weber, M.; Brunotte, K.; Rothgänger, M.; Petersen, T.; Siegmund, M.; Peddinghaus, J. (2022): Load-adapted surface modifications to increase lifetime of forging dies. 25th International Conference on Metal Forming ESAFORM, 27.04.-29.04.2022 – Talk.

Paschke, H.; Weber, M.; Brunotte, K.; Rothgänger, M.; Petersen, T.; Siegmund, M.; Peddinghaus, J. (2022): Adhesion reducing surface modifications on aluminum processing tools. 18th International Conference on Plasma Surface Engineering, 12.09.-15.09.2022 – Talk.

Paschke, H.; Lauth, M.; Grydin, O. (2022): Surface modifications to reduce the adhesion of aluminum during twin roll casting. 23rd International Conference on Advances in Materials and Processing Technologies AMPT, 10.10.-14.10.2022 – Talk.

Peddinghaus, J.; Paschke, H.; Brunotte, K.; Behrens, B.-A. (2022): 'Adhäsions- und Schädigungsverhalten von Duplex-behandelten Werkzeugen beim Gesenkschmieden von Aluminiumlegierungen. XLI. Verformungskundliches Kolloquium VKK, 18.-22.03.23 – Talk.

Reinders, P. M. (2022): Investigations on the corrosion behavior of plasma-nitrided austenitic stainless steels. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Reus, J., Hain, K., Tidau, M., Finke, J.H., Lachmann, K. (2022) Functionalization of 3D-printed tablets by atmospheric pressure plasma coating. Transactions on Additive Manufacturing Meets Medicine 2022. DOI: 10.18416/AMMM.2022.2209661 – Talk.

Schneider, M., Bruns, S., Galonska, K., Vergöhl, M., Henning, P., Melzig, T. (2022). Sputtering platform for double-sided precision optical coatings. Conference "Oxide-based Materials and Devices" 2022. https://doi.org/10.1117/12.2607764

Schott, A., Rekowski, M., Grötzinger, K., Ehrbrecht, B., Herrmann, C. (2022): Development of thin-film sensors for data acquisition in cold forging tools. WGP - Congress of the German Academic Association for Production Technology, 11.10.-14.10.2022 – Talk.

Schrepfer, A., Schott, A., Trober, P., Keunecke, M., Welm, M., Steinlehner, F., Golle, R., Volk, W. (2022): Reduction of adhesive wear with use of tool coating reducing thermoelectric currents. International Deep-Drawing Research Group Conference IDDRG 2022, Lorient, France, 6.6.-10.6.2022 – Talk.

Sittinger, V., Baron, S, Höfer, M, Harig, T. (2022): Hot-filament CVD diamond coatings for optical applications. 65th Annual SVC Technical Conference, 2.5.-5.5.2022 – Talk.

Sittinger, V., King, H., Kabakli Ö. S., Schulze, P. and Goldschmidt, J. C. (2022): Indium-based transparent conductive oxides developed for perovskite and perovskite-silicon tandem solar cell applications. 65th Annual SVC Technical Conference, 2.5.-5.5.2022 – Talk.

Sittinger, V., King, H., Stoll, D., Kaiser, A., Jung, S. (2022): Indium-based transparent conductive oxides for perovskite silicon tandem solar cells. 8th International Symposium on Transparent Oxide and Related Materials for Electronics and Optics, Greece – Talk.

Stein, C. (2022): CVD diamond coatings for co-free cemented carbide tool materials. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Stein, C. (2022): Thermal barrier tool coatings for thermoforming of FRP, thermal film properties and first forming-tests. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Poster.

Conference contributions

Stein, C. (2022): Thermal barrier tool coatings for thermoforming of FRP, thermal film properties and first forming-tests. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Poster.

Thomas, M. (2022): Surface engineering with atmospheric-pressure plasmas. 18. International Conference on Plasma Surface Engineering, 12.9.-15.9.2022 – Talk.

Weber, S., Wolff, D., Grube, M., Dilger, N., Zellmer, S. (2022a). Technical, Economic and Ecological Evaluation of Production Processes for Solid-State-Batteries. International Bunsen Discussion Meeting Solid-State Batteries 2022. – Talk.

Weber, S., Wolff, D., Grube, M., Voges, K., Dilger, N., Cerdas Marin, J. F., Zellmer, S. (2022b). Environmental assessment of sulfidic all-solid-state battery pouch cell production. International Battery Production Conference, 7.11.-9.11.2022. https://doi.org/10.24406/publica-1159 – Poster

Weber, S., Wolff, D., Grube, M., Voges, K., Dilger, N., Cerdas Marin, J. F., Zellmer, S. (2022c). Sulfide-based all-solid-state battery pouch cell production - an environmental assessment. International Bunsen Discussion Meeting Solid-State Batteries 2022 – Poster. https://doi.org/10.24406/publica-1160

Wilde, A.-S., Czarski, M., Schott, A., Abraham, T., Herrmann, C. (2022): Utilizing artificial intelligence for virtual quality gates in changeable production systems. WGP - Congress of the German Academic Association for Production Technology, 11.10.-14.10.2022 – Talk.

Picture index

Cover: TU Braunschweig, Photo: Tom Bauer
2, 3: Fraunhofer IST, Photo: Ulrike Balhorn
8: Fraunhofer IST, Photo: Paul Kurze
10, 11: B+T Unternehmensgruppe
12, 13, Graphic: Nils Hildebrandt
14, 15, Graphic: Nils Hildebrandt
18, Figure 1-8: Fraunhofer IST, Photos: Ulrike Balhorn
18, Figure 9: Fraunhofer WKI, Photo: Manuela Lingnau
19-21, Figure 10-28: Fraunhofer IST, Photos: Ulrike Balhorn
21, Figure 28: HAWK
21, Figure 30: TU Braunschweig
22, Figure 1: Fraunhofer IST, Photo: Paul Kurze
22, Figure 2: Fraunhofer ISE, Photo: Joachim Went
23, Figure 3, 4: skbs/Björn Petersen
24, 25: Fraunhofer, Max Niemann
26, 27: Fraunhofer IST
28: Fraunhofer IST, Photo: Paul Kurze
28, Logo: Arbeitgeberverband Region Braunschweig e. V.
29: DLR
30: IHK Braunschweig, Photo: Andreas Rudolph
31: B+T Unternehmensgruppe, Photo: Norbert Kaufmann
33: TU Braunschweig, Photo: Tom Bauer
34, 35, Figure 1, 3, 4: Fraunhofer IST, Photo: Paul Kurze
34, Figure 2: Fraunhofer IST, Photo: Linus Burkel
35, Figure 4: HAWK, Photo: Clara Valentin
36: Fraunhofer IST
37, 38: TU Braunschweig, Tom Bauer
42, 44: Fraunhofer IST, Photo: Nils Hendrik Mueller
45, Figure 2: Unsplash, Photo: Lenny Kuhne
45, Figure 3: Fraunhofer IST, Photo: Manuela Lingnau
45, Figure 4: Fraunhofer IST, Photo: Falko Oldenburg
46: Fraunhofer IST, Photo: Ulrike Balhorn
47, Figure 2, 3: IPH – Institut für Integrierte Produktion Hannover gGmbH
47, Figure 4: Fraunhofer IST
48, Figure 1: Fraunhofer IST, Photo: Ulrike Balhorn
48, Figure 2: Fraunhofer IIS
49: Figure 3, 4: Fraunhofer IST
50, 51: Fraunhofer IST
52: Fraunhofer IST, Photo: Falko Oldenburg
53: Fraunhofer IST
54: rawpixels.com - stock.adobe.com
56, 57, 59: Fraunhofer IST
60, 62: Fraunhofer IST, Photo: Nils Hendrik Mueller
63: Fraunhofer IST, Photo: Falko Oldenburg
64: Salzgitter AG
66, 67: Fraunhofer IST
68: Fraunhofer IST, Photo: Rainer Meier, BFF Wittmar
71, Figure 1: Fraunhofer WK, Photo: Manuela Lingnau
71, Figure 2: Courtesy NASA/JPL-Caltech
71, Figure 3: Fraunhofer IST, Photo: Falko Oldenburg
73: Fraunhofer
74, 75: Fraunhofer IST, Illustration: Falko Oldenburg
76, 78, Figure 1: Fraunhofer IST, Photo: Falko Oldenburg
78, Figure 2: Fraunhofer IST, Photo: Krees Nagel
80: Fraunhofer IST, Photo: Paul Kurze
81: Fraunhofer IST
82: Fraunhofer IST, Photo: Thomas Neubert
83: Fraunhofer IST, Photo: Kevin Hain
84: Fraunhofer IST, Photo: Nils Hendrik Mueller
86: Fraunhofer IST, Photo: Jan Benz
87, 89, 90: Fraunhofer IST
92, Figure 1: Pexels
92, Figure 2: Fraunhofer IST
93, Figure 3, 4: Fraunhofer IST, Photo: Nils Hendrik Mueller
95: Fraunhofer IST, Photo: Paul Kurze
96, 97: Graphic: Nils Hildebrandt
98: Fraunhofer, Photo: Markus Jürgens
98, 99: adobe.stock.com
99: Fraunhofer
103: Fraunhofer IST
104: Fraunhofer IST
105: INPLAS

Imprint

Fraunhofer Institute for Surface
Engineering and Thin Films IST

Director
Prof. Dr.-Ing. Christoph Herrmann

Deputy Director
Dr. Lothar Schäfer

Riedenkamp 2
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
Sandra Yoshizawa
Daniela Kleinschmidt

Layout
nils hildebrandt designer
www.nilshildebrandt-designer.de

Contact

Fraunhofer Institute for Surface
Engineering and Thin Films IST
Riedenkamp 2
38108 Braunschweig, Germany
Phone +49 531 2155-0
Fax +49 531 2155-900
info@ist.fraunhofer.de

www.ist.fraunhofer.de