



Fraunhofer Institute for
Surface Engineering and Thin Films IST

Annual Report 2025

Fraunhofer IST



Annual Report 2025



Foreword

Ladies and Gentlemen,

the year 2025 has once again demonstrated that thin-film and surface technology is a key technology for innovative and sustainable products. We are particularly proud of two awards: At the Optical Interference Coatings Conference (OIC2025) in the United States, we won the Manufacturing Challenge with our EOSS® technology platform. The task involved creating an interference coating that ultimately reveals the image of a roadrunner – a challenge our team mastered brilliantly. In addition, we received the Fraunhofer Future Foundation's "Innovations for a Better Future" award – presented for the first time – for the PreCare project on mobile healthcare in Africa.

At Fraunhofer IST, we take a systemic approach. We develop competitive and scalable production systems, create solutions for a circular economy, and enable new, sustainable energy systems.

At the Wasserstoff Campus Salzgitter, the focus is on advancing innovative hydrogen technologies and their production processes, as well as on developing digital simulation models for holistic value chains in the future hydrogen economy. In Braunschweig, the research facility for the Fraunhofer Center for Energy Storage and Systems ZESS is emerging as a central component of the regional BLB+ battery ecosystem, and in Wolfsburg, an innovation campus is taking shape where we at Fraunhofer CCEM, together with

the TU Braunschweig, Ostfalia University of Applied Sciences, and industry partners, are developing solutions for the automotive circular economy.

Looking ahead with confidence, we look forward to working with you to advance new ideas and bring further innovations to fruition. We would like to thank you – our partners in research and development, our industrial clients, our sponsors, colleagues, and friends – for your trust and collaboration.

I would like to take this opportunity to extend my special thanks to the Institute's staff, whose performance, commitment, trust, and support help ensure that Fraunhofer IST acts as a catalyst for innovative developments and helps shape our future.

I hope you enjoy reading this.

With very best regards

Prof. Dr.-Ing. Christoph Herrmann
Director

Contents

Foreword	3
Contents	4
Our board of trustees	8
Outstanding collaboration	10
Interview with Werner Schiller, CEO of Rohloff AG	
Institute profile	12
Where to find us – our locations	14
The institute in figures	20
Professorships at the Technische Universität Braunschweig	22
Your contact persons	24
Institute management, administration and central services	26
Departmental, group and team management	26
Locations / Centers	29
Highlights	30
Future Day at Fraunhofer IST	30
Fraunhofer IST successfully contributes to the publication of ISO standard 10678	31
Award-wining	32
Fraunhofer research team wins the “Innovations for a Better Future” award	32
Victory thanks to double-sided precision coating	34
In conversations at trade fairs and events	36
Embracing diversity – shaping inclusion	42
Asked and answered.... ..	44
Continuing education at Fraunhofer IST	46

In focus: Precision in layers – High-Performance Optical Coatings	48
High-precision coatings for the next generation of optics	54
Two generations of the EOSS® coating platform	58
Applications of precision optics	50
Shaping the future with precision	62
Our expertise across the entire process chain	64
Sustainable battery and hydrogen systems	67
Focus on the circular economy – for the energy of tomorrow	67
From research: Ammonia as the key to hydrogen supply	68
From research: Cross-sectional analysis of particulate layers	72
Sustainability management and Life Cycle Engineering	75
Practical sustainability solutions for German industry	75
From research: Green steel for Germany and Australia	76
Circular products and processes	79
Innovative surface technology as the key to the circular economy	79
From Research: COAD® –	
Sustainable plasma coating for controlled adhesion	80
Medical engineering and pharmaceutical systems	83
Where interfaces make medical applications possible	83
From Research: Custom-designed chemically reactive surfaces	
produced via 3D printing	84
Optical and electronic systems	87
Precision coatings for future technologies	87
From research: Precise plant analyses for sustainable agriculture	88
From research: An alternative approach to satellite climate control	90
Diamond-based systems	93
Efficient, durable and robust components for industrial applications	93
From research: Determination of optical constants	
of large-area diamond coatings	94
From Research: Automated visual inspection for production	96
Tribology, corrosion and sensor technology	99
Smart surfaces for innovative products and processes	99
From Research: Boride surfaces for high-temperature applications	100

Contents

Fraunhofer IST in networks 102

 The Fraunhofer-Gesellschaft 104

 Networks within the Fraunhofer-Gesellschaft 106

 Fraunhofer Group for Production 108

 Regional and nationwide networking 110

 The Competence Network for Industrial Plasma Surface Technology e.V. 112

Memberships, Publications, Theses, Patents Granted 114

Conference Papers 114

List of Figures 117

Legal Notice 118



Our board of trustees

Interface between research and practice

Our illustrious Board of Trustees is comprised of representatives from science, business and public life. The members of our Board of Trustees provide us with advice and support on issues relating to our professional orientation and structural changes, and endow our institute with important impetus. During the reporting year, we bid farewell to our long-standing Chairman, Dr. Philipp Lichtenauer, expressing our deep gratitude for his many years of dedicated service. At the same time, we are delighted that Frank Benner has assumed the chairmanship of the Board of Trustees and that our collaboration will continue under this new leadership.



Chairman
Frank Benner / B+T Unternehmensgruppe

Prof. Dr. Peter Awakowicz / Ruhr-Universität Bochum

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

Dr. med. Thomas Bartkiewicz / Harzklinikum Dorothea Christiane Erxleben GmbH

Cordula Miosga / Arbeitgeberverband Region Braunschweig e. V.

Dr.-Ing. Marko Gernuks / Volkswagen AG

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Uwe Heydenreich / TRUMPF Hüttinger GmbH + Co. KG

Dr.-Ing. Stefan Rinck

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

Dr. Elke Sternberger-Rützel / Haro Höfliger Verpackungsmaschinen GmbH (by 2026)

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

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Dr. Kai U. Ziegler / EagleBurgmann Germany GmbH & Co. KG

Prof. Dr. Simone Kauffeld / Technische Universität Braunschweig

Excellent collaboration

An interview with Werner Schiller, CEO at Rohloff AG

The development of high-precision bicycle hub gears places the highest demands on materials, process reliability, and sustainability. In collaboration with the Fraunhofer Institute for Surface Engineering and Thin Films IST and the equipment manufacturer Tantec A/S, Rohloff AG has succeeded in implementing an innovative solution for the targeted optimization of coating processes using the COAD® plasma process. This collaborative partnership combines application-oriented research, industrial implementation, and environmental responsibility – and serves as a prime example of how successful technology transfer works in practice.



Components for high-precision bicycle gear systems are coated in a plasma environment using the COAD® process.

What are the current challenges facing your industry, and how is Fraunhofer IST contributing?

The bicycle industry faces the challenge of developing increasingly complex and durable products while meeting ever-stricter sustainability requirements. In our drivetrains, components must function reliably in extremely confined spaces – particularly when it comes to sealing metal parts. Conventional methods are increasingly reaching their limits in this regard, both technically and environmentally. Fraunhofer IST is making a decisive contribution here by developing innovative, solvent-free plasma processes that are specifically tailored to our requirements. Through a combination of deep process understanding, modern surface analysis, and industry-oriented implementation, adhesion problems have been permanently resolved and existing production processes significantly improved.”



The headquarters of Rohloff AG in Kassel-Fulda.

You have been working in collaboration with the Fraunhofer IST since 2022. Which project stands out as particularly distinctive in your collaboration with the Fraunhofer IST?

One outstanding project is the joint development and industrial implementation of the COAD® plasma process for controlled adhesion. The starting point was a specific adhesion problem with the sealing of our hub gearboxes that could not be solved using standard methods. Together with Fraunhofer IST and Tantec A/S, the process was developed step by step, optimized, and finally integrated into a specially adapted VacuTEC system. The system has been in successful use in our production since June 2024. The close, practical collaboration – from process development and system integration to the training of our employees – was particularly impressive. The result is a reliable, sustainable, and production-ready solution.”

What plans do you have for the future, particularly in relation to the Fraunhofer IST?

We intend to continue strengthening our collaboration with Fraunhofer IST in the future. Our goal is to expand the COAD® process to additional applications and components and to jointly address new challenges related to adhesion, cleaning, and surface functionalization. Furthermore, we see great potential in the development of new technologies for the reconditioning of components. Here, we are pioneers in the field of sustainability, as our hub gears can be remanufactured at our plant, enabling customers to achieve very long service lives. The combination of scientific excellence and industrial implementation expertise makes Fraunhofer IST a strategic partner for us in bringing innovations to series production in a sustainable manner and further expanding our technological leadership.”

Personal details

Werner Schiller is the CEO of Rohloff AG and has led the family-run company, based in Fulda, since 2018. The company is internationally recognized as a premium manufacturer of high-precision bicycle hub gears.

Under his leadership, the focus is consistently on the continuous development of products and processes to ensure the highest levels of reliability, durability, and quality. A central component of his strategic approach is close collaboration with research partners. Of particular importance to him is the close integration of application-oriented research, plant engineering, and production. His aspirations extend beyond mere technical excellence: solutions should not only be functionally convincing, but also sustainable and economical. This approach shapes both the collaboration with partners and the long-term technological direction of Rohloff AG.



More information about the COAD® process for controlled adhesion in high-precision bicycle components:



Institute profile

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, including plant and mechanical engineering, tools, vehicle construction, aerospace, renewable energy, optics, medical and pharmaceutical process engineering, circular economy, electronics, and the semiconductor industry.

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.

Further core competencies of the Fraunhofer IST are:

- Sustainable battery and hydrogen systems
- Sustainability management and life cycle engineering
- Circular products and processes
- Medical technology and pharmaceutical systems
- Optical and electronic systems
- Diamond-based tools, components, and sensor systems
- Tribology, corrosion, and sensor technology

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 and a circular economy using 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.

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).

Where to find us – our locations



Wolfsburg

- Fraunhofer Center Circular Economy for Mobility CCEM



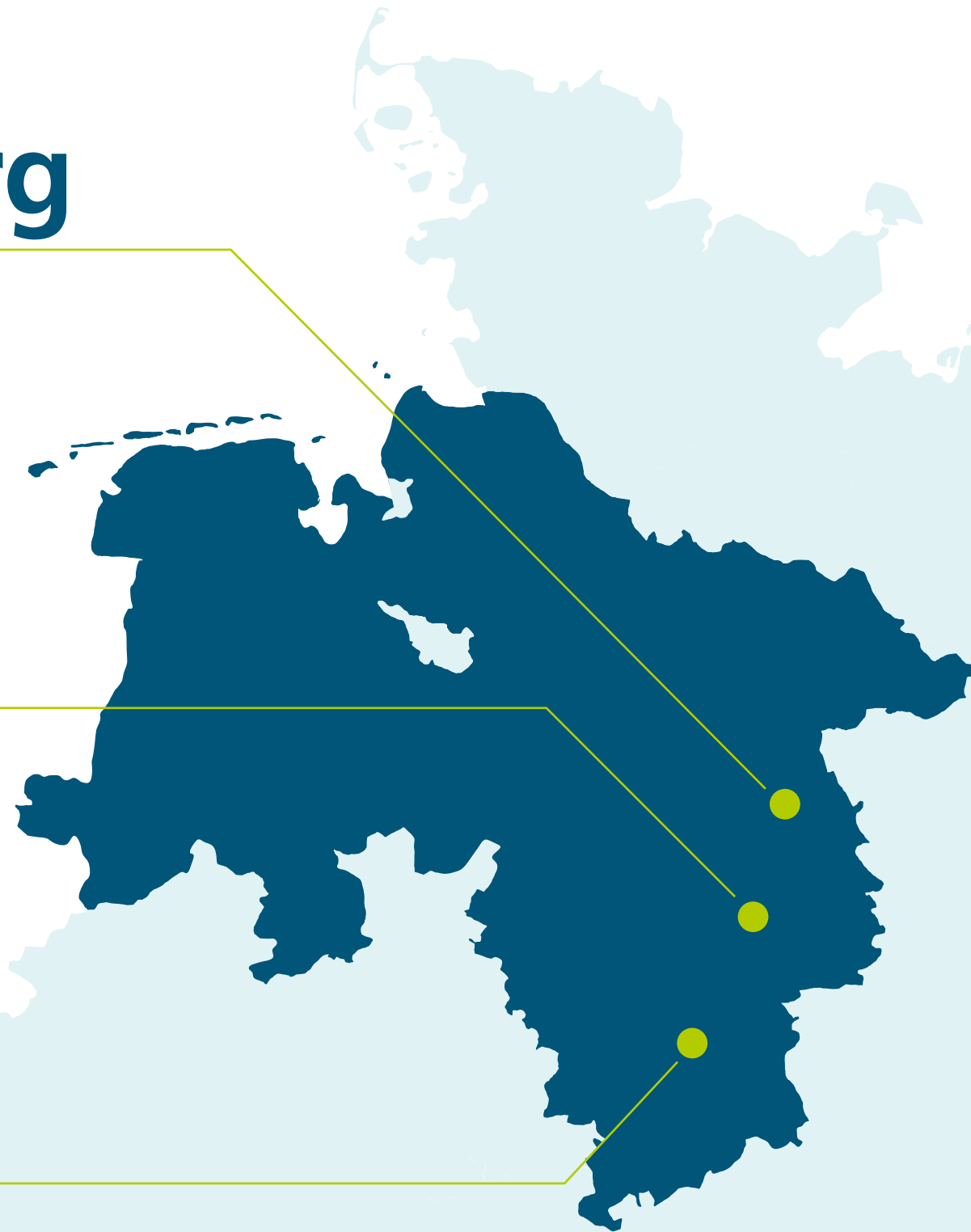
Braunschweig

- Fraunhofer Institute for Surface Engineering and Thin Films IST (Main location)
- Fraunhofer Center for Energy Storage and Systems ZESS



Salzgitter

- Wasserstoff Campus Salzgitter e. V.



Fraunhofer Institute for Surface Engineering and Thin Films IST

Address:
Riedenkamp 2
38108 Braunschweig
Germany



Office premises:
2,000 m²
Laboratory premises:
5,500 m²

Contact:
info@ist.fraunhofer.de
Phone +49 531 2155-0

Focus areas:
Thematic focuses at our main location encompass the areas of tribology, corrosion, and sensor technology, optics, diamond technology and medical technology as well as sustainability management, simulation, analytics and testing technology.



Energy storage



Fraunhofer Center for Energy Storage and Systems ZESS

Address:
Herrmann-Blenk-Straße 43
38108 Braunschweig

Office and laboratory premises:
3,400 m²



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Focus areas:
At the Fraunhofer Center for Energy Storage and Systems ZESS, the Fraunhofer institutes IST, IFAM, and IKTS work closely with the Technische Universität Braunschweig and, as an associated partner of the BLB+ regional network, to develop next-generation sustainable energy storage systems and advance them to market maturity. Our research focuses on lithium solid-state batteries, sodium-nickel-chloride batteries, and hydrogen technologies. We examine the entire life cycle of energy storage systems – from raw materials through various production steps and use to recycling, thereby taking technical, economic and ecological aspects into consideration.

Mobility



Wasserstoff Campus Salzgitter e. V.

Address:
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John-F.-Kennedy-Straße 43-53
38228 Salzgitter
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Contact:
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christoph.imdahl@ist.fraunhofer.de
Phone +49 531 2155-669

Focus areas:
At the Wasserstoff Campus Salzgitter e. V., we conduct research into sustainable hydrogen technologies along the entire value chain. Founded by nine key players from business, science and politics, the Campus operates as a flagship project for the demonstration of a decarbonized industrial region in the hydrogen economy. Research focuses are climate-neutral sectors through the coupling of decarbonized factories and districts, closed material and product cycles, and flexible production processes. The Campus is striving towards further growth, new partnerships and research into fuel cells, electrolyzers and CO₂-neutral factories. The further training of specialists and the promotion of global partnerships are also key objectives.

Office premises:
320 m²

Laboratory premises:
1,580 m²



Fraunhofer Center Circular Economy for Mobility CCEM

Address:
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Contact:
Prof. Dr. Michael Thomas
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Phone +49 531 2155-525

Office premises:
350 work places*

Laboratory premises:
2,800 m² technical center of
the OHLF

Focus areas:
In the Fraunhofer CCEM, the Fraunhofer IST, together with the Fraunhofer institutes IFAM, IWU and WKI, pools its expertise in the research topics of automated production systems, future interior concepts, Life Cycle Engineering and sustainable product design. In collaboration with research partners, the Fraunhofer IST is working towards the goal of developing and evaluating new materials, production techniques and digital methods in an economically and ecologically sustainable manner. In order to achieve this, procedures for automated dismantling, Re-X processes such as cleaning, remanufacturing and re-use as well as sustainable surface processes along a circular process chain are utilized and the large-scale testing of these technologies is driven forward.

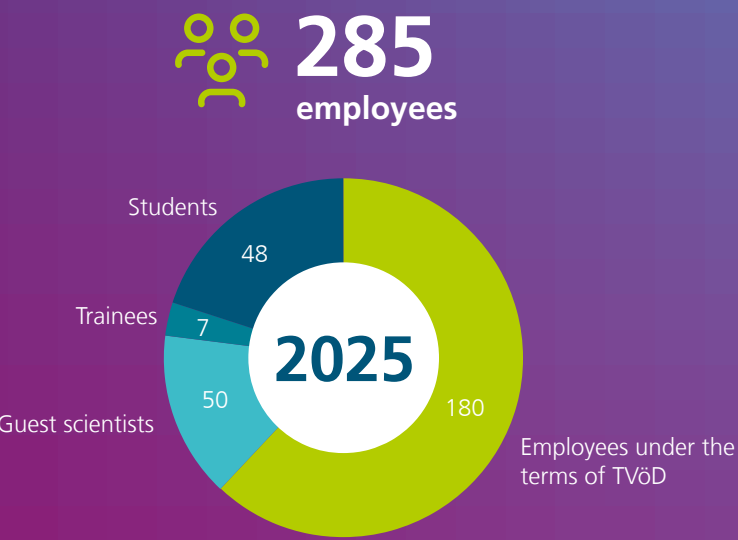
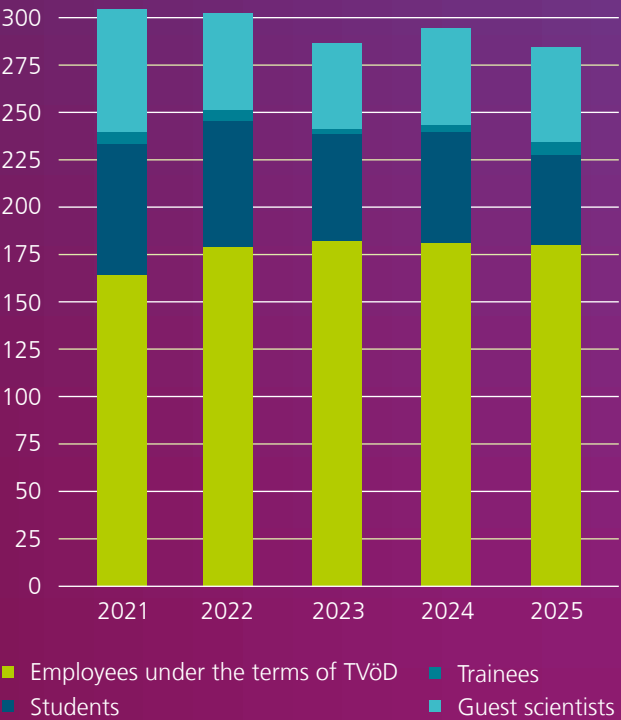
*For OHLF e.V., Fraunhofer-Gesellschaft, TU Braunschweig and industry.



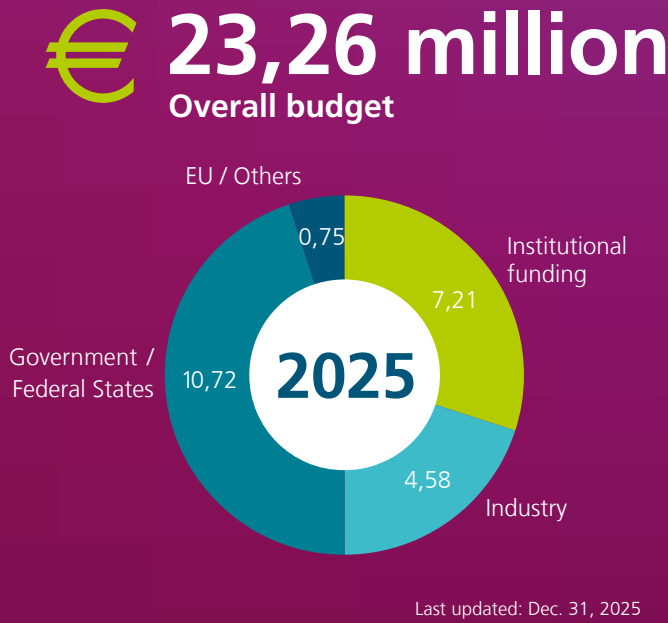
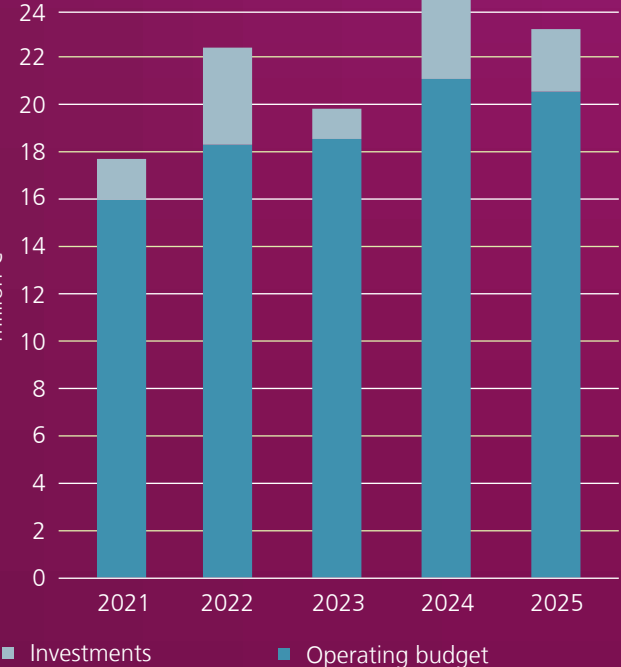
Hydrogen

The institute in figures

Personnel development



Overall budget



52
conference contributions

8
professorships

59
student assistants

17
nationalities

3,3%
disabled-employee quota

67,1%
32,9%
employees
under the terms of TVöD

6
women in
leadership positions

>15
disciplines

5
locations

5
vocational professions

160
Instagram followers

4219
LinkedIn followers

Professorships at the Technische Universität Braunschweig

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 eight associated professorships.

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 / disassembly
- 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
- Circular Economy

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
- Recycling and (re-)synthesis

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. Claus-Peter Klages

Research foci:

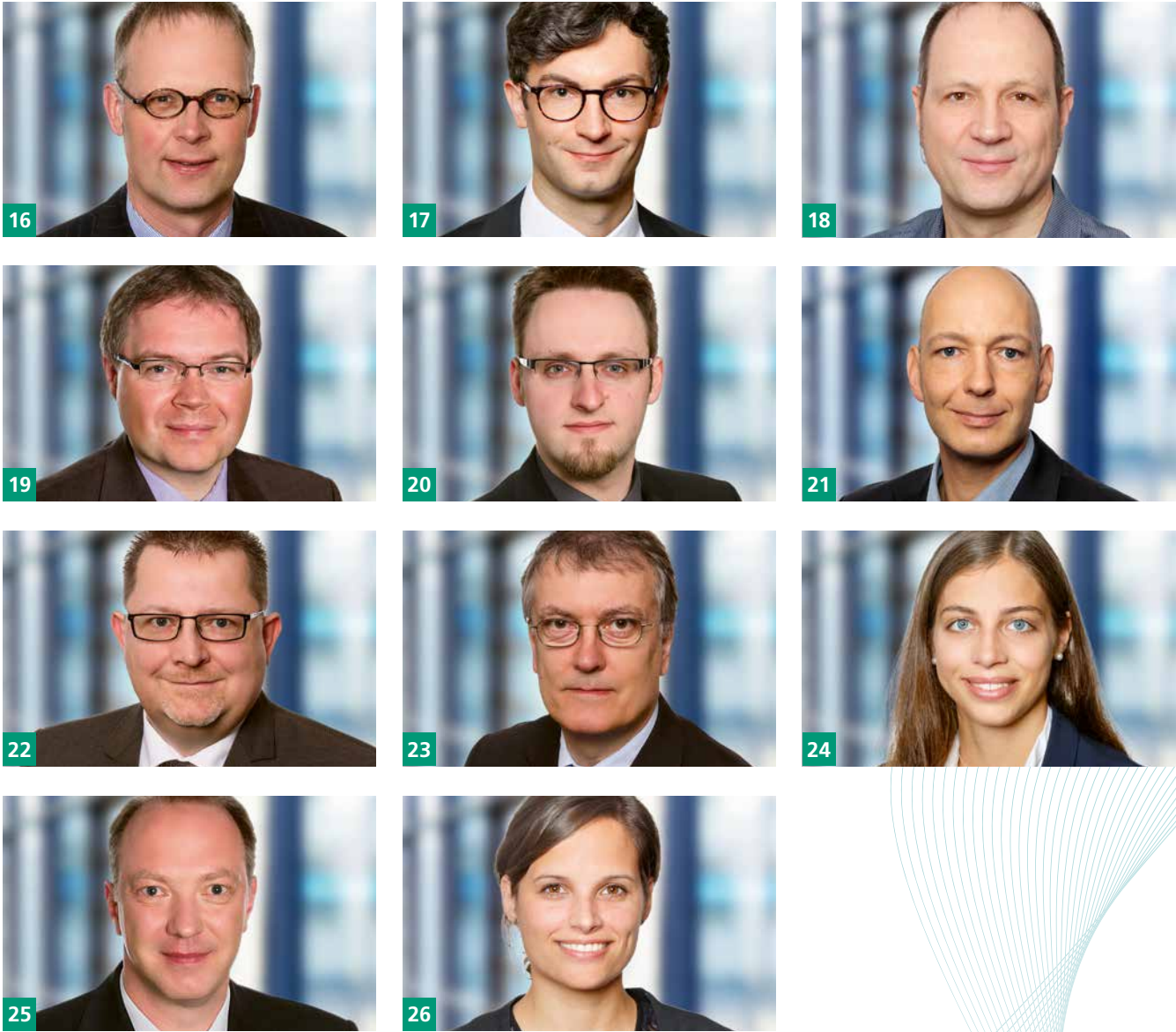
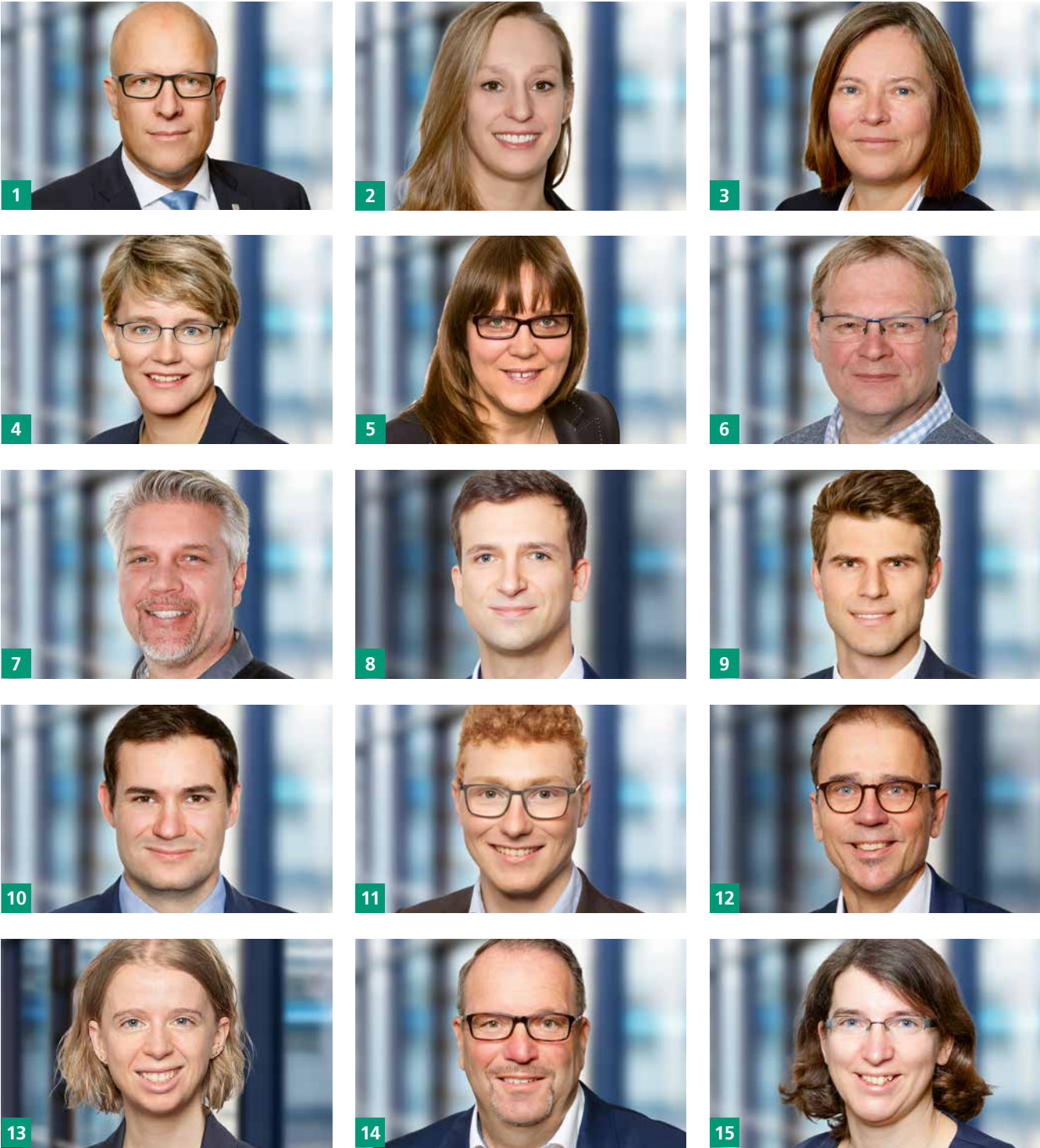
- Atmospheric pressure plasma processes
- Surface functionalization
- Plasma chemistry

Prof. Dr. Michael Thomas (Honorary professorship)

Research foci:

- Interfacial chemistry
- Atmospheric pressure plasma processes
- Surface technologies for circular processes

Your contact persons



Institute management, administration and central services

Institute Director

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Deputy Director

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Departmental, group and team management

Sustainable battery and hydrogen systems

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Material and process development

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Product development and design / Production and conditioning of energy storage materials / Production of battery components and further processing into coin and pouch cells / Reconditioning and recycling / Particle, material and process simulation

Sustainable process chains for battery systems

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Life cycle engineering for energy storage technologies / Planning, modelling, simulation of process chains / Digitization of production / Sensor technology for energy storage systems

Sustainable hydrogen systems and technologies

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Digital methods for energy conversion chains and simulation of sustainable factory systems / Manufacture and recycling of fuel-cell components, modules and systems / Automated assembly and testing of fuel-cell stacks

Analytics and quality assurance

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Dr.-Ing. Sebastian Melzig ⁸

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Chemical micro-range analysis / Microscopy and surface measurement / Mechanical characterization / Friction and wear measurement / Testing technology / Customer-specific testing methods / Commissioned investigations

Sustainability management and Life Cycle Engineering

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Sustainability management

Advice on corporate sustainability strategy of companies / Decarbonization target derivation and implementation / Sustainable Development Goals (SDGs) / Materiality analysis / Resource efficiency and circular economy / Learning concepts on sustainability management and life cycle assessment

Life Cycle Engineering

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Technical measures for environmental impact reduction / Life cycle-based tools and methods for holistic product and process optimization / Life cycle engineering and life cycle costing / Hotspot analyses / Certified carbon and water footprints / Roadmaps for decarbonization and circular economy

Circular products and processes

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Plasma-based recycling processes for complex components / Automated systems for cleaning, remanufacturing and functionalization / Sustainable materials and surfaces for interior and exterior components / COAD® process for targeted adhesion / Circular economy

Medical technology and pharmaceutical systems

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Phone +49 531 2155-683
Surface technology for pharmaceutical production and primary packaging / Adhesion control on medical devices / Cleaning and sanitation / Atmospheric pressure plasmas (process and source development) / Chemical functionalization

Optical and electronic systems

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Precision optical coatings

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Production technology for optical interference filters / Measurement technology for process control and quality assurance / Development and demonstration of filters in accordance with customer specifications

Simulation and thin-film systems

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Optical, electrical and magnetic functional layers / Large-area coating / Gas-flow sputtering technology / High power impulse magnetron sputtering (HIPIMS) / Sensor technology / Simulation of plasma and gaseous fluxes (PICMC) / Digital analysis and optimization of coating processes / Prediction of particle and aerosole movement (PALADIN) / CFD simulation (computational fluid dynamics) / Software development / Cyber-physical systems (digital twin)

Diamond-based systems

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Atomic layer deposition

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Coating processes for medical products / Coating of 3D substrates for micro-optics and membranes / Particle coating / Catalyst deposition for energy conversion and systems

Hot-wire CVD

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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

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Tribology, corrosion, and sensor technology

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Micro and sensor technology

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Tribological systems

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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

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Flexible production systems for surface technology / Bio-inspired processes and products / Bio-based coolants and lubricants

Corrosion protection and electroplating

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Electroplating / Electrochemical processes / Wet-chemical processes / Corrosion testing / Digitization

Locations / Centers

Fraunhofer Center for Energy Storage and Systems ZESS

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Dr.-Ing. Jutta Janßen ²⁶
jutta.janssen@ist.fraunhofer.de | Phone +49 531 2155-613
Development of mobile and stationary energy storage systems / Development and scaling of process technologies / Battery production / Process engineering / Design of the production system for energy storage systems / Life Cycle Management

Fraunhofer Center Circular Economy for Mobility CCEM

Prof. Dr. Michael Thomas ¹³
michael.thomas@ist.fraunhofer.de | Phone +49 531 2155-525
Automated cleaning and treatment processes / Functional and smart surfaces / Application of bio-based and secondary materials / Future interior concepts / Life Cycle Engineering and sustainable product design

Wasserstoff Campus Salzgitter e.V. (engl. Hydrogen Campus Salzgitter)

Christoph Imdahl M.Sc. ¹⁰
christoph.imdahl@ist.fraunhofer.de | Phone +49 531 2155-669
Hydrogen technologies / Hydrogen economy / Circular economy / Network building / Sector coupling / Sustainable factory systems / Decarbonization of industry / Continuing education



The pupils painted the showpieces according to their own preferences.

The young people were able to gain practical experience at the Fraunhofer IST.

Future Day at the Fraunhofer IST Hands-on research experience

April 04, 2025 / How is a wafer-thin film created? Why is the correct preparation so important? And how can the quality of a coating be tested? These and many other questions were investigated by 22 curious schoolchildren during this year's Future Day at the Fraunhofer Institute for Surface Engineering and Thin Films IST. In collaboration with the neighboring Fraunhofer WKI, the institute opened its doors to provide the young guests with an exciting insight into the world of research and technology.

Following a brief introduction to the work of the two institutes, the practical part began: First, the 10-to-15-year-olds learned about the importance of a clean surface and observed the cleaning process in a 14-metre-long system. Then things became creative - the pupils painted and labeled showpieces, which were subsequently coated. At the PVD coating system, they were able to experience first-hand how an extremely thin film is applied. Finally, they went to the analytics department, where exciting things from everyday life were examined under the microscope. The children enthusiastically took home not only their self-designed works, but also new impressions from the world of research. "It is always such a pleasure to see how curious and adventurous the children are," said the team from the Fraunhofer IST. "Perhaps we will see some of them again in a few years - as trainees or students."

The Fraunhofer IST offers apprenticeships in technical and administrative professions, as well as a versatile range of possibilities for students - from internships through to final theses.

Scientific basis and development

The work began back in 2013 with a regular revision of the existing ISO standard. The review, which is conducted every five years, revealed that the test conditions for highly active samples had altered significantly over time. As German experts had originally published the standard in 2008 as the first "self-cleaning standard" worldwide, the review was assigned to the German Institute for Standardization DIN. The head of the DIN working group "Photocatalytic self-cleaning" at this time was the graduate engineer Frank Neumann, an employee of the Fraunhofer IST, which therefore took charge of the process. In collaboration with other representatives of the DIN committee, members of the French network "Association française de normalisation AFNOR" and representatives of the "Japanese Industrial Standards Committee JISC", the contents of the standard were revised, whereby the experts took into account the current state-of-the-art as well as opinions received concerning drafts of the standard. The aim was to create an internationally recognized and technically precise standard that corresponds to the latest scientific knowledge. Following a number of international consultations, the finalized standard was published in December 2024.

Fraunhofer IST successfully contributes towards the publication of ISO standard 10678

April 09, 2025 / The international standard ISO 10678 regulates the procedure for determining the photocatalytic activity of surfaces by means of the degradation of methylene blue under UV irradiation. It enables an objective assessment of the self-cleaning properties of surfaces and provides manufacturers of coated materials with a reliable basis for product certification.

Photocatalytically active surfaces contribute towards the degradation of organic soiling such as exhaust gases, fats or soot by means of light energy. In the presence of sunlight, a certain degree of self-cleaning effect can be achieved in façades, and glass surfaces require less frequent cleaning. As a result, not only are maintenance costs reduced, but savings are also made on cleaning agents and water – a significant

advantage for the environment and sustainability. ISO 10678 creates a reliable basis for this and ensures that both the methodology and the photocatalytic properties of products are verifiable and comparable. In particular for manufacturers of self-cleaning tiles, glass, roof tiles, wall paints or textiles, the standard offers a reliable possibility for proving the effectiveness of their products and, consequently, providing consumers with clear orientation.

The publication of ISO 10678 marks an important milestone. The next scheduled review of the standard will take place in 2029. In the meantime, the Fraunhofer IST offers testing in accordance with DIN 52980 and ISO 10678 in order to enable manufacturers to reliably evaluate their products.

Methylene blue measuring station according to DIN 52980 and ISO standard 10678.

Award-winning



Maintenance of the PreCare platform will be handled by S Mile Solutions (Pty) Ltd in collaboration with local partners. S Mile is a Fraunhofer spin-off from the PreCare project.



The care unit provides storage space and the energy supply for diverse medical devices, active substances and tests.



On stage with Prof. Hans-Jörg Bullinger (left), Chairman of the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation), and Prof. Holger Hanselka (right), President of the Fraunhofer-Gesellschaft: The award recipients Frank Neumann (2nd from left), Dr. Simone Kondruweit-Reinema (center), and Dr. Joachim Koschikowski (2nd from right) received the “Innovations for a Better Future” award from the Fraunhofer Future Foundation.

Innovations for a Better Future award from the Fraunhofer Future Foundation

In 2025, the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation) is presenting its Innovations for a Better Future award for the first time. This award recognizes the achievements of a Fraunhofer team that has succeeded in translating a technological solution into practice, thereby making a special contribution to sustainable development in line with the UN Sustainable Development Goals (SDGs). The prize, which is endowed with 50,000 euros, is made possible thanks to generous support from private donors.

Health platform for pickup trucks

Fraunhofer research team wins the “Innovations for a Better Future” award

June 04, 2025 / Around the world, there is a lack of comprehensive medical care for people living in remote areas. Researchers at the Fraunhofer Institute for Surface Engineering and Thin Films IST and the Fraunhofer Institute for Solar Energy Systems ISE have devised a solution for this in the PreCare project: a flexible, modular health platform that can be installed on the bed of a pickup truck. It is already in use in South Africa and Namibia. The team was presented with the Innovations for a Better Future award from the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation) for this development.

People living in remote, hard-to-access areas often receive little to no medical care. Aside from the difficulty of simply getting around, with underdeveloped road networks and lack of means of transportation, there is also a shortage of medical staff. Across many countries in Africa, it is not uncommon for there to be only one doctor for every 10,000 people.

For comparison, there are an average of 44 physicians providing care for every 10,000 people in Germany.

To help people in these regions get access to needed care, researchers have developed a rugged health platform that can be installed on the bed of all-terrain pickup trucks, offering all the infrastructure needed to perform health checks, packed into a tiny space. Even rough dirt or gravel roads are no longer an obstacle.

On the platform, electrical equipment like the built-in refrigeration system for medications, vaccines and blood samples is operated via an independent power supply that relies on solar panels and battery storage. There is even a water purification system on board. A system based on diamond-coated electrodes makes it possible to produce disinfectants from a simple sodium chloride solution while in the field. To compare treatment data and provide telemedicine services, a communication system that uses

satellite or mobile networks can be incorporated. Diagnostic equipment such as portable X-ray, EKG and ultrasound units can be added as well.

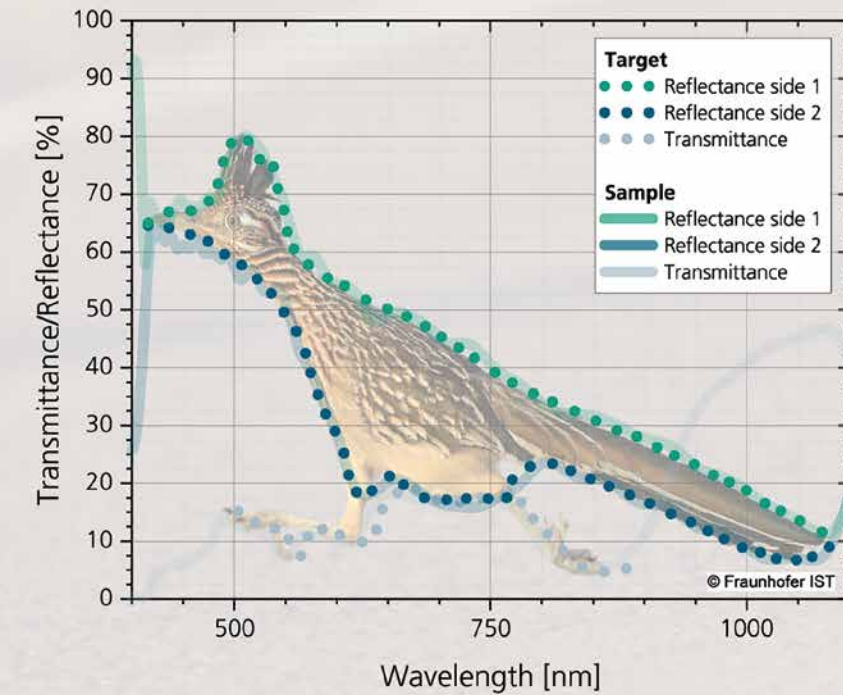
The project has featured extensive collaboration with a wide range of local stakeholders. The first prototype was delivered to an NGO in South Africa in 2023.

Funding from the Fraunhofer Future Foundation subsequently made it possible to develop a second prototype, which is now being operated by an NGO in Namibia. Local partners in healthcare, research, systems construction and logistics in sub-Saharan Africa were included from an early stage. S Mile Solutions (Pty) Ltd, which was founded during the project, is now handling the manufacturing, sales and maintenance. It is Fraunhofer’s first spin-off in South Africa.

TRANSFER for Our
FUTURE
2025



The task of the Manufacturing Challenge as part of OIC 2025: Design an interference coating that ultimately produces this image of a roadrunner.



The result of the Manufacturing Challenge: the reflection and transmission curves of an optical filter in Roadrunner design.

Double-sided precision coating led to victory

Fraunhofer IST wins OIC2025 Manufacturing Challenge with optical filter in roadrunner design

July 09, 2025 / With the utmost precision, the Fraunhofer Institute for Surface Engineering and Thin Films IST has won this year's Manufacturing Challenge at the Optical Interference Coatings Conference (OIC2025) in the USA. In this international competition, a spectroscopically precisely defined optical filter had to be manufactured as accurately as possible – a task that demands both creativity and the highest precision in design, production, and measurement technology. The first place among the worldwide entries is impressive proof of the institute's outstanding expertise in the field of optical coatings.

"This year, an interference coating was to be designed in such a way that it would ultimately produce the image of a roadrunner, i.e. a running bird," explained Dipl.-Phys. Stefan Bruns, award winner and Senior Scientist at the Fraunhofer IST. "To achieve this, we utilized our high-precision EOSS® coating plants, with which we were able to create coatings on both sides – a key prerequisite for this complex task."

The challenge thereby was to develop an optical stack that united three different spectral features: The top of the bird was to be visible in the reflection of the front side, while its underside should be visible in the reflection of the reverse side. In addition, the characteristic appearance of the feet had to be visible in the transmission range. This complex design was only technically feasible through the precise control of layer thicknesses, optical constants and oxidation behavior.

"This task required not only exceptional technical skill, but also the close intermeshing of simulation, production, and measurement technology," continued Mr. Bruns. "We are delighted that we were able to secure first place with our solution. Participating in the OIC2025 Challenge was not only an exciting scientific challenge for us, but also a possibility to demonstrate our technological expertise in an international context. We would, of course, like to take part again next time."



Dipl.-Phys. Stefan Bruns, award winner and Senior Scientist at Fraunhofer IST.



In conversations at trade fairs and events

Whether at trade fairs, conferences, or career days, Fraunhofer IST was present at numerous events in 2025, showcasing its latest research findings and engaging in direct dialogue with experts from academia and industry. A particular focus was once again on recruiting: at job and career fairs, the team actively connected with young talent and provided information about entry opportunities and career paths at Fraunhofer IST.



**Industry workshop:
Process Control in Production Lines**

January 21 and 22, 2025 / Together with PLASUS GmbH, Fraunhofer IST organized an industry workshop on the topic of “Process Control in Production Lines – Latest Developments and Future Trends”. On the first day of the workshop, presentations alternated with opportunities for interactive discussion and product demonstrations. On the second day, participants had the opportunity to experience the topic firsthand through practical experiments.

Research up close: On the second day of the industry workshop “Process Control in Production Lines,” participants gained insights into process monitoring and control at three interactive stations – ranging from High Power Impulse Magnetron Sputtering (HIPIMS) and PECVD applications to inline coating monitoring at Fraunhofer IST.

“TransferTalk” special edition

March 28, 2025 / On the occasion of the “Tag der Raumfahrt” (engl. German Space Day) the online dialogue format “TransferTalk – Industry Meets Science” offered an exclusive look at innovations, groundbreaking technologies, and exciting developments in the space industry. In two short talks, experts from Fraunhofer IST showcased the current state of their research: in his lecture “Living on the Moon,” Dr. Andreas Dietz explained whether and how the Moon could become a new home, while Dr. Michael Vergöhl explored the topic “Invisible helpers: How high-tech coatings are changing our view of space and the Earth”.



At HANNOVER MESSE, the Fraunhofer IST trade fair team presented the Wasserstoff Campus Salzgitter. Prof. Angela Ittel, President of TU Braunschweig, was among the visitors to the exhibition booth.

Innovations from Lower Saxony at HANNOVER MESSE and automatica

March 31, 2025 - April 04, 2025 / At HANNOVER MESSE, Fraunhofer IST was represented as a partner of Wasserstoff Campus Salzgitter e.V. at the joint booth of the State of Lower Saxony. A model of the campus on a 1:50 scale and a video illustrated the wide range of applications offered by Wasserstoff Campus Salzgitter e.V. to its members and provided insights into selected projects.

June 24 - 27, 2025 / At automatica 2025, Fraunhofer IST presented wear-resistant thin-film sensors that measure temperature and pressure profiles directly within the mold during plastic injection molding. In combination with machine learning, they enable automated process monitoring, immediately detect disturbances, and provide real-time indications of component quality. The sensor technology is also suitable for materials with a high glass fiber or recycled content, thereby supporting sustainable production. Interested visitors could experience how the system works at the joint Fraunhofer booth of the AutoMOBILE Production Alliance.

In dialogue with researchers from the region

June 18, 2025 / At the Salon der Wissenschaft 2025 (engl. Salon of Science) in Braunschweig, exchange and networking were once again at the center of attention. Dr. Dennis Barton from Fraunhofer IST discussed with participants the role of digital twins and simulation models in research and highlighted the limitations of virtual experiments.



The Salon der Wissenschaft does not rely on traditional lectures, but instead focuses on direct exchange. In several parallel discussion rounds, attendees have the opportunity to engage in personal conversations with researchers from the Braunschweig region on topics such as sustainability, climate protection, digitalization, healthcare, mobility, and education. Those not actively participating in the discussions can join in via headphones and listen.



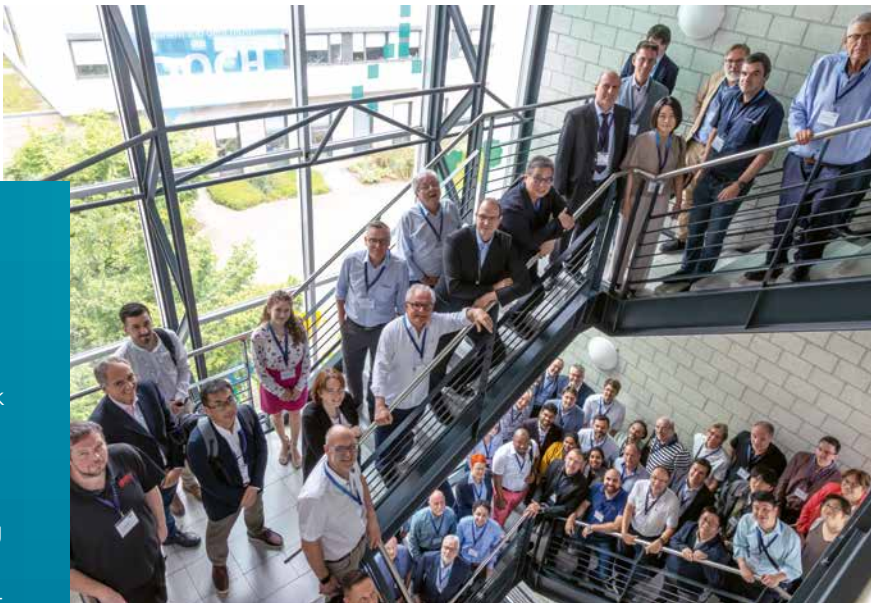
Infrared optics for extreme demands

June 24 - 27, 2025 / High-performance, environmentally stable infrared optics are essential for modern applications in analytics, security and aerospace. At LASER World of Photonics 2025, the Fraunhofer Institute for Surface Engineering and Thin Films IST will be presenting newly developed coating solutions that offer maximum precision and long-term stability – even under extreme conditions.

The trade fair team at LASER 2025 – our experts in the development and process control of optical coatings.

HIPIMS 2025: Focusing on the future of coating technology

June 25 - 26, 2025 / Around 90 participants from 17 countries accepted the invitation from the Fraunhofer IST and the co-organizers – the Competence Network Industrial Plasma Surface Technology e.V. INPLAS, Sheffield Hallam University, and the Fraunhofer Innovation Platform for Surface and Production Engineering for Optical and Electrical Systems at Feng Chia University (FIP-SPE@FCU) – to take part in the world’s only conference dedicated exclusively to high-power impulse sputtering in research and application. This was the first time that the conference had been held at the Fraunhofer IST. A comprehensive program was offered, comprised of technical presentations on current developments and applications of HIPIMS technology, fundamental physical processes, plasma diagnostics and simulations, and aspects of digital transformation in vacuum coating technology.





Under the motto of the Fraunhofer-Gesellschaft employer branding campaign, “Change starts with us,” the Fraunhofer IST recruiting team was represented at several job fairs during the reporting year.

Change starts with us.

In 2025, the Fraunhofer IST recruiting team was once again on the road to inspire pupils and students about career opportunities at the institute. Their stops included events such as “My Start into Apprenticeship,” the Bachelor Information Evening on Production, Automation and Systems, vocatium Braunschweig/Wolfsburg, the bonding company contact fair, the Night of Applicants, SHIFT NOW, and BONI – Practical Career Orientation. A particular highlight: at the bonding fair, Fraunhofer IST was honored as “Studi’s Liebling” – the favorite company of students in Braunschweig.

The Fraunhofer IST job fair team is delighted to have been named the students’ favorite company at the “bonding” career fair.



German National Hydrogen Council pays a visit to Salzgitter

The visit of the National Hydrogen Council to the Wasserstoff Campus Salzgitter not only underlined the campus’s central role as a location for the research, development and industrial application of hydrogen technologies, but also promoted the exchange between science, business, politics and civil society.

November 27, 2025 / At the end of the reporting year, a delegation from the German National Hydrogen Council visited the Wasserstoff Campus Salzgitter. The National Hydrogen Council, which is comprised of 23 high-ranking experts from business, science and civil society, was appointed by the German government in June 2020 and acts as an independent, non-partisan advisory body. The visit provided an opportunity to present the activities, expertise and innovative strength of the Campus at a national level. Among other things, the delegation was able to obtain an impression regarding modern production and testing infrastructures. They visited the automated stack-(dis) assembly line operated by the Fraunhofer IST, which is utilized within the framework of various research projects conducted by the TU Braunschweig and the Fraunhofer IST.

Embracing diversity – shaping inclusion

At Fraunhofer IST, we are actively committed to creating a work environment in which everyone is welcomed, valued, and included – regardless of physical, cognitive, or mental abilities. To this end, Fraunhofer IST, as one of 10 institutes of the Fraunhofer-Gesellschaft, participated in a several-month-long Inclusion Support Program designed to raise the visibility of people with disabilities in science and pave the way for an inclusive work culture.

Research thrives on diversity, and innovation arises where different perspectives come together. To foster this, structural conditions must be created that enable and actively promote the participation of people with disabilities. The Fraunhofer-Gesellschaft is strategically committed to this cause: accessibility, inclusive recruitment, collaboration and networking, and the elimination of unconscious biases are the key areas of focus.



Disability awareness workshop at Fraunhofer IST: Employees experience barriers firsthand – by navigating in a wheelchair, wearing simulation goggles that simulate visual impairments, and testing a white cane. These hands-on exercises raise awareness of different perspectives and highlight the importance of an accessible work environment.



Joint site visit at Fraunhofer IST: At various locations – from the accessible parking spot to the interior signage and the technical center – barriers were identified, perspectives were exchanged, and concrete steps were developed to improve accessibility in everyday work.

The Inclusion Support Program – practical and effective

All participating institutes went through a multi-stage program consisting of workshops, coaching sessions, and mentoring by people with disabilities, with the goal of laying the groundwork for an inclusive corporate culture.

The program covered the following topics:

- Accessibility
- Job postings
- Accessible websites and communication
- Mock job application training
- Disability awareness workshop
- Recruiting strategies
- Practical advice and individual feedback

The program thus offered not only theoretical knowledge and practical methods, but also provided opportunities for direct on-site experience. A key focus was therefore a site inspection of the institute building and the surrounding grounds with regard to accessibility. This involved a comprehensive review of the entrances, pathways, wayfinding systems, and reception area, as well as workstations, restrooms, meeting rooms, the cafeteria, and the digital infrastructure. The goal was to identify existing barriers, gain new perspectives, and derive concrete measures to further improve accessibility.

Participation in the Inclusion Support Program made it clear that inclusion is not a niche topic, but a strategic area for the future. Structural change becomes possible when visibility, internal capacity building, and external partnerships work together. At the same time, it became clear: Inclusion does not end with a project – it begins in everyday life.



As part of the Inclusion Support Program, the Fraunhofer IST project team is committed to fostering a diverse and accessible workplace – through innovative ideas, dedication, and teamwork – with the goal of sustainably promoting an inclusive institutional culture.



Asked and answered...

Breaking down barriers, opening up opportunities

The Representative for Disabled Employees is committed to protecting the interests of employees with disabilities at the Fraunhofer IST. In this interview, Ann-Katrin Otte, Deputy Representative for Employees with Severe Disabilities, explains her responsibilities, how the institute promotes inclusion and accessibility, and what goals she is pursuing for the future. She shares practical experiences, everyday challenges, and how diversity can be put into practice in the workplace.



Dear Ann-Katrin, what role does the representative body for employees with severe disabilities play at the Fraunhofer IST, and what tasks do you undertake in this context?

|| The German Social Code IX (SGB IX) regulates the rehabilitation and participation of people with disabilities in Germany, including the tasks of the Schwerbehindertenvertretung (SBV; representative body for employees with severe disabilities). In general, the SBV represents and promotes the interests of disabled employees and employees with equivalent status at the institute. For example, the SBV monitors the entire recruitment process and ensures compliance with legal regulations. It provides the employer with information regarding rights and obligations and ensures that no discrimination occurs during the selection and recruitment process. In the subsequent employment relationship, the SBV provides support in the procurement of work aids, the needs-oriented configuration of the workplace, any necessary applications, and in helping to raise awareness. These challenges constitute part of my role as Deputy Representative for Disabled Employees at the Fraunhofer IST. Through my work with the people concerned and the constantly changing initial situations, I am continually learning new things in this area, which makes the task really varied."

|| In my experience, people with disabilities are able to identify their weaknesses clearly and thoughtfully, and this is also a great strength, because it is the only way to provide employees with the best possible support."

Ann-Katrin Otte

What measures has the Fraunhofer IST already implemented in order to promote inclusion and accessibility?

|| We have formed an inclusion team in order to identify barriers from different perspectives and to further strengthen inclusion in our corporate culture. In our roles as employees in communications, recruiting and science, as equal-opportunities officers and as Deputy Representative for Disabled Employees, we are the direct interface for the promotion of accessibility and the rapid implementation of measures for change. We also regularly involve experts, such as our Buildings Officer, in our discussions. For us, the topic of inclusion and accessibility is an ongoing and evolving process. We therefore take part in an accompanying program for the inclusion and participation of disabled people in working life and we also receive coaching from external mentors."

What are your wishes or specific goals for the future in terms of inclusion and accessibility at Fraunhofer?

|| For me, inclusion and the removal of barriers begins when open communication takes place, as this is the only way in which a natural understanding can develop regarding the fact that people have different needs and that these are independent of a disability. My wish – and what I continue to advocate – is that disability is not a stigma and does not reveal anything about a person's performance capabilities."



Continuing education at Fraunhofer IST

In the 2025 reporting year, Fraunhofer IST conducted five continuing education programs. In addition to established offerings in the field of hydrogen, new areas of focus were introduced, particularly in sustainability, life cycle assessment, and the fundamental principles of natural sciences. The programs combined e-learning, live online formats, and in-person events and were characterized by a strong practical focus. An overview of our programs:

Net Zero Scenario – how to achieve it with hydrogen

In the English-language course “Net Zero Scenario,” participants gained in-depth insights into the key elements of green hydrogen production, transport, and application, as well as their significance for a climate-neutral economy. The course was aimed specifically at management representatives, engineers, and employees of municipal utility companies. The course combined e-learning modules and live online sessions with an intensive two-day in-person workshop at the Hydrogen Campus in Salzgitter.

Pilot training: HySecunda – Practical knowledge for hydrogen projects

The pilot training course “Practical knowledge for hydrogen projects” was conducted as part of the “HySecunda – Green Hydrogen Production in South Africa” project. The goal was to provide a comprehensive understanding of the planning

and implementation of hydrogen production projects. The target audience included, in particular, project planners, such as computer scientists and engineers, as well as management representatives. The course consisted of online training modules featuring e-learning and self-study assignments, as well as a practice-oriented field trip week.

Pilot training: think GREEN, act SMART II Life cycle assessment – methodological approach

The pilot training program “think GREEN, act SMART II” was designed to specifically expand the range of continuing education offerings in the field of sustainability. Participants gained in-depth insights into the methodology of life cycle assessment according to ISO 14040/44 and learned to identify challenges throughout the various phases of a life cycle assessment. The course was designed for sustainability officers and was offered as a combination of e-learning modules, live online courses, and workshops.

Fundamentals of chemistry: Knowledge that opens new horizons

As part of the program “Fundamentals of chemistry: Knowledge that opens new horizons,” a variety of courses provide a solid foundation for understanding chemical concepts in technology-driven fields. Participants delved into key topics such as atomic structure, chemical bonds, reactions, electrochemistry, analytical methods, and occupational safety. The goal was to equip employees with the ability to technically classify chemical processes and handle hazardous substances responsibly.

The training can serve as preparation for work in areas such as battery cell manufacturing, semiconductor production, hydrogen technologies, and recycling, and is individually tailored to the client’s needs by experts from the relevant departments. The course was conducted on a company-specific basis during the reporting year and can also be flexibly offered in hybrid or fully online formats.

Your benefits at a glance

- Direct transfer of knowledge from current research to practice
- Highly practical and directly applicable
- Flexible, target-group-specific learning formats
- Valuable networking and exchange opportunities with experts from industry and research

EPR for batteries: Rethinking the cycle

The continuing education program “EPR (Extended Producer Responsibility) for batteries” covered the fundamentals of the life cycle, design, and manufacturing of batteries, as well as current recycling strategies and legal frameworks. The course was aimed at professionals from industry and government who deal with issues related to extended producer responsibility. The hybrid format included e-learning modules, live online sessions, and in-person components.

For information on our current selection of continuing education programs, please visit our website:



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In focus: Precision in layers

HIGH-PERFORMANCE OPTICAL COATINGS

for the future

Precision optics are a key enabling technology in modern systems: From digital communication and autonomous systems to medical engineering, the performance of optical applications is largely determined by sophisticated coatings. At the same time, demands on manufacturing and process control are increasing. State-of-the-art coating equipment and data-driven processes make it possible to reliably produce these complex coating stacks with high precision, stability, and productivity.

Megatrends are driving demand for precision optics

Digital transformation, connected mobility, and medical engineering are dynamically driving the global photonics market. Camera systems in smartphones and vehicles, LiDAR sensors and machine vision, hyperspectral Earth observation, semiconductor manufacturing, and AR/VR are generating a rapidly growing demand for precision optical thin films. These applications require extremely tight tolerances, low losses, and high long-term stability – often on thin substrates and at the wafer scale. At the same time, expectations for productivity, automation, cleanroom integration, and data-driven process control are rising.

The market is growing correspondingly accordingly: The global photonics industry reached a volume of approximately 865 billion USD in 2022 with annual growth of about six to seven percent. In Germany, the industry generated around 50 billion EUR in 2024¹. The components and materials segment is developing particularly strongly – and with it, optical filters and coatings. For these systems, this translates into increasing unit volumes, more complex designs with hundreds to thousands of layers (10 to 100 μm total thickness), as well as tighter specifications for uniformity (up to 99.8 percent) and reproducible gradient profiles. New device generations – from autonomous sensors and medical diagnostics to small satellites – also require more compact, lighter, and more energy-efficient solutions.

¹ Spectaris, Trend Report Photonics 2025/2026

Precision meets industrial robustness

To meet this demand in the long term, production systems are needed that combine highest precision with industrial robustness. This calls for stable sputtering processes without reactive gas drift, long tool life, simultaneous double-sided coating for thin wafers, as well as precise in-situ monitoring and software-based control. In this way, yield, throughput, and quality can be increased simultaneously – a prerequisite for competitive precision optics “Made in Europe.”

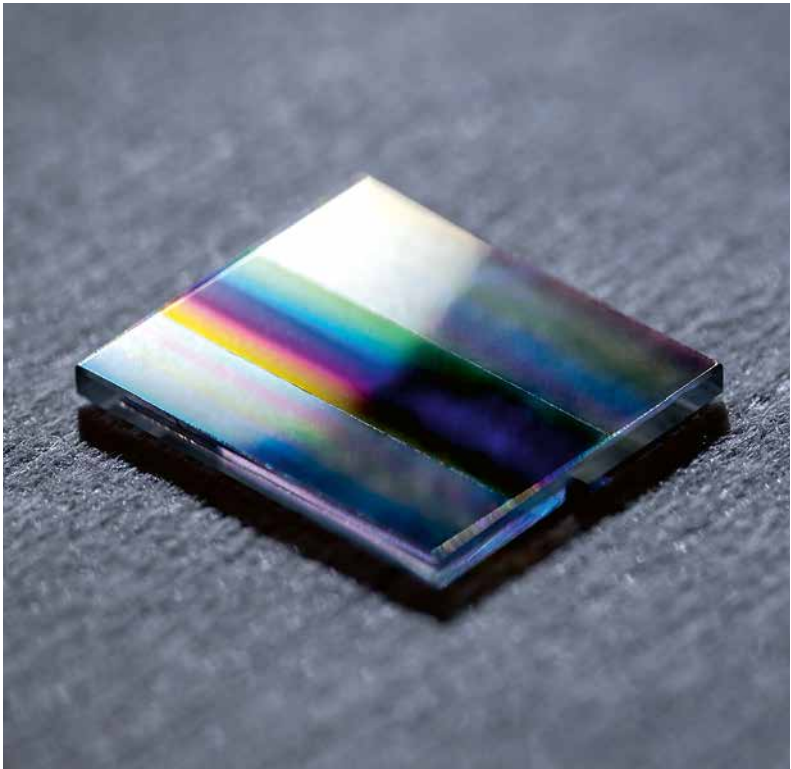
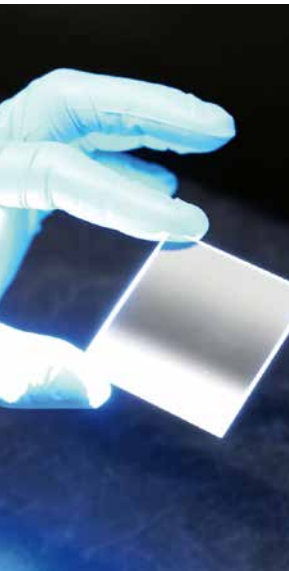
Trends and requirements of new device generations

Today, wafer-level filters and filter-on-chip solutions, laser-resistant coatings for security and medical engineering, as well as multi-gradient filters for compact spectroscopy systems are particularly in demand – all of which can only be manufactured economically with reproducible high precision. At the same time, in light of global supply chain risks, the need for scalable manufacturing capacities in Europe is growing.



Photonics is one of the key technologies of our time. High-precision optical coatings determine the performance of sensors, laser systems, and satellite instruments. With our coating technologies, we lay the groundwork for the reliable and scalable production of these optical systems.”

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



The extremely compact hyperspectral filter combines three linearly variable bandpass filters, including broadband blocking, on a substrate measuring just 10 mm. In the finished instrument, this filter is positioned directly in front of the camera chip, enabling highly precise spectral analysis.

Technology in focus

The technology combines dual rotatable cylindrical cathodes , which enable constant deposition rates and homogeneous distributions without geometric drift, with reactive-gas-free sputtering cathodes based on mixed targets. A spatially separated plasma post-reaction ensures maximum process stability and precise control of layer stoichiometry. The upward-facing coating geometry reduces particle contamination, while simultaneous double-sided coating stabilizes thin substrates and simultaneously increases throughput. This system concept is complemented by MOCCA[®], a model- and data-driven control and monitoring software with integrated in-situ transmission measurement and spectroscopic ellipsometry. This enables uniformities close to 100 percent over long production periods, as well as controlled gradient profiles and wafer-level filters.

Precision optics as an invisible key technology

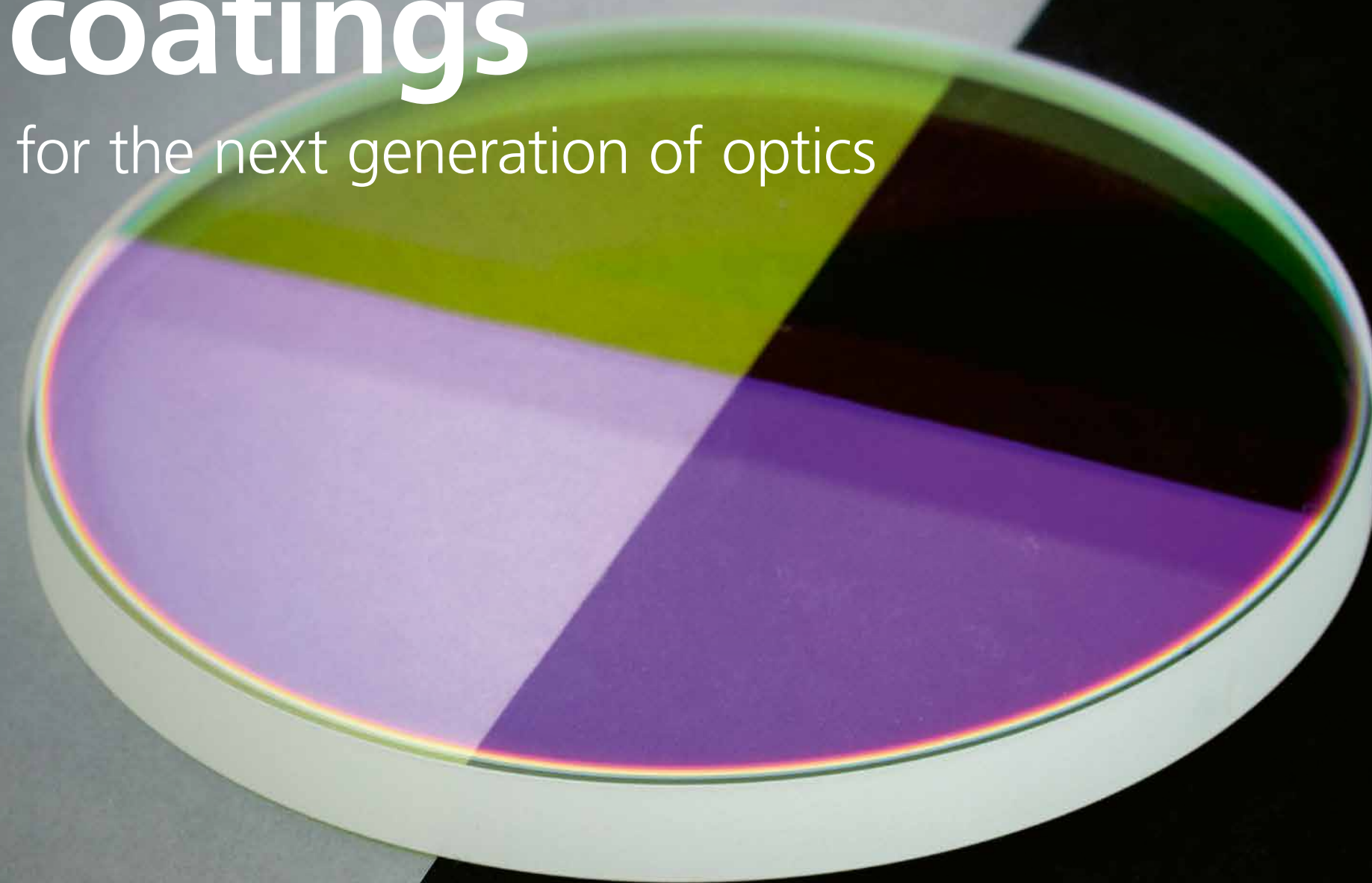
Precision optics have become an essential building block of modern high-tech applications: It determines the performance of LiDAR systems and machine vision, as well as the safety and image quality of medical diagnostic devices, process control in semiconductor manufacturing, and the functionality of modern AR/VR displays. Space-qualified sensor technology and future applications such as quantum communication are also virtually impossible to realize without high-precision optical coating stacks. What matters here is not only the design of complex interference coatings with hundreds to thousands of layers. Equally important is their reproducible implementation under industrial conditions – with extreme requirements for uniformity, low optical losses, stable polarization and phase responses, and high productivity. Innovative coating technologies address precisely this challenge: system platforms such as EOSS[®] and EOSS[®]/OPTA X combine stable sputtering processes with geometrically stable sources, low-particle system designs, and data-driven process control.

Precision

Overcoming barriers

High-precision coatings

for the next generation of optics



A dielectric beam splitter consisting of approximately 100 individual layers with high reflectance in the range of 750 to 850 nm and high transmission in the range of 450 to 745 nm.

In precision optics, a fraction of a nanometer can make the difference between success and failure. But rising performance requirements and complex multilayer systems are pushing traditional coating methods to their limits – making new technologies indispensable.

Precision on the nanometer scale is crucial in precision optics. Even slight deviations in layer thickness can significantly influence the spectral properties of optical filters: bandgaps shift, and phase and polarization properties change. In complex multilayer systems with hundreds to thousands of layers, such deviations accumulate and lead to spectral drifts and wavefront errors.

Aspheric plano-convex lenses with a coating thickness gradient.



Key requirements for optical coatings

- Layer thickness control in the nanometer range
- Maximum and stable uniformity close to 100 percent across the entire wafer
- Multi-layer systems with hundreds to thousands of layers
- Total coating thicknesses from 10 to 100 μm
- Stable processes for 24/7 industrial operation

The challenge lies not only in the precision of individual layers, but in the reproducible fabrication of complex multilayer systems over long production cycles. To achieve this, we need system designs that combine stability, process control, and productivity."

Dr. Philipp Farr, Group Manager Precision Optical Coatings



Process control at an industrial plant: MOCCA® user interface during the coating of a cavity filter.

Increasing demands on materials and processes

As the demands of modern applications grow, so do the technical challenges. These include the need for maximum homogeneity across wafers and batches, controlled layer stress management to prevent so-called "bow" deformation of thin substrates, and low-particle processes to ensure yield and laser resistance. At the same time, production processes must enable high deposition rates and long, stable production runs.

New generations of devices further intensify these requirements: Thin glass or silicon wafers with thicknesses ranging from 100 to 250 µm, filter-on-chip devices, or complex multilayer systems with total thicknesses of up to 100 µm demand precisely defined gradient profiles and tolerances in the parts-per-thousand range.

Limitations of conventional methods

Many conventional coating methods reach their limits here. Planar cathodes change their geometry during operation due to erosion, which can lead to variations in coating rate and distribution. Partially reactive sputtering is susceptible to fluctuations caused by reactive gases, while manually flipping substrates poses additional risks, particularly with thin wafers. Other methods, such as atomic layer deposition (ALD), are often too slow for thick multilayer stacks.

New system concepts and process control methods are therefore needed: geometrically stable sources, reactive-gas-free cathode processes with separate post-reaction, simultaneous double-sided coating, and model- and data-based in-situ control. These enable reproducible high precision on an industrial scale – even with increasing production volumes.

MOCCA® broadband monitoring system for automating optical coatings.



Cleanroom for preparing coating processes on the FHR.Star EOSS® using the first-generation EOSS® technology from Fraunhofer IST.

Precision meets productivity

Two generations of the EOSS® coating platform

The production of complex optical coating stacks requires precise interaction between equipment, process control, and monitoring. The EOSS® platform combines robust system technology with data-driven process control. The CARS process ensures precise oxide layers, while MOCCA® monitors deposition rates, stoichiometry, and gradient profiles in real time – delivering reproducible precision optics on an industrial scale.

A platform for precision optical coatings

EOSS® (Enhanced Optical Sputtering System) is the industrially proven platform for precision optical coatings developed at Fraunhofer IST. The first generation, implemented as the FHR.Star EOSS®, introduced key technological concepts: a rotating substrate holder, dual rotatable cylindrical cathodes, and reactive-gas-free mixed-target processes. The upward-facing geometry reduces particle contamination, while integrated in-situ measurement methods enable stable process control. This allows uniformities of more than 99.8 percent to be achieved over periods of several weeks. In this system configuration, double-sided coating is still performed by manually turning the substrates.

Second Generation: EOSS®/OPTA X

The second generation of the platform significantly expands this concept. OPTA X systems enable simultaneous double-sided coating of substrates – a decisive advantage for thin wafers or glass substrates, as well as sensitive optical components. At the same time, longer service life, higher deposition rates, and automated workflows enable stable 24/7 operation with increased throughput.

Digital process control with MOCCA+®

The MOCCA+® software platform complements these system concepts with model- and data-driven control and monitoring of the processes. In-situ measurement techniques such as broadband transmission measurement, optical plasma monitoring, or spectroscopic ellipsometry enable precise control of deposition rate, stoichiometry, and layer thickness distribution.

CARS process for stable oxide layers

At the heart of this development is the CARS process (Compound-assisted reactive sputtering). In this process, sputtering occurs without reactive gas directly at the cathode, while the chemical reaction for oxide formation takes place spatially separated in a downstream plasma. The result is stoichiometrically precise, low-loss oxide layers with high process stability.

This combination of a stable hardware platform and data-driven process control enables scalable precision optics – from wafer-level filters to complex multi-gradient filters for applications in the automotive industry, semiconductor manufacturing, medical engineering, and aerospace.



OPTA X coating system (by Ardenne) featuring our second-generation EOSS® technology for simultaneous deposition on both sides of interference filters.



With the EOSS® platform, we combine the highest level of optical precision with industrial productivity. The key lies in the interplay between robust system technology, innovative process concepts, and data-driven process control."

Dipl.-Phys. Stefan Bruns, Senior Scientist

High-tech for practical applications

Applications of precision optics

Modern sensor technology depends on precision and reliability – from autonomous vehicles and medical diagnostic devices to space applications. Fraunhofer IST transfers new coating processes from research into practical use, and thus enables optical filters that combine top performance with industrial scalability.

Key components of modern sensor systems

Optical filter systems are central components of modern sensor systems. In autonomous mobility, for example, they enable the precise spectral separation of signal and stray light in LiDAR systems or cameras. In medical engineering, they ensure

high-resolution imaging and reliable diagnostic procedures. Fraunhofer IST sees itself as a bridge between fundamental research and industrial implementation. Together with industry partners, new coating processes are developed, optimized, and translated into scalable production solutions.

Wide range of applications

In addition to the automotive industry and medical engineering, the semiconductor industry, aerospace, and compact spectroscopy systems also benefit from precision optical coatings. Multilayer filters, laser-resistant protective coatings, or gradient coatings enable new generations of devices with higher performance and a more compact designs.

We bridge the gap between research and industry – and make precision coatings for modern sensor systems reliable and scalable.”

Dr. Michael Vergöhl, Head of Department Optical and Electronic Systems

Shaping the future

Precision optical coatings will continue to play a central role in numerous high-tech applications in the future. With its coating technologies and equipment platforms, Fraunhofer IST is helping to further develop this key technology and make it available for industrial use.

The goal is to combine innovative processes, digital process control, and scalable system concepts in such a way that high-precision optical coating stacks can be manufactured economically even in large quantities. In doing so, the institute also strengthens Europe's technological sovereignty in a strategically important field of technology.

At the same time, new applications – for example in aerospace, security-relevant systems, or modern sensor systems – are opening up additional opportunities for precision optical technologies.

Together with industry partners, Fraunhofer IST is working to drive these developments forward and to drive innovative coating solutions from research into industrial practice.



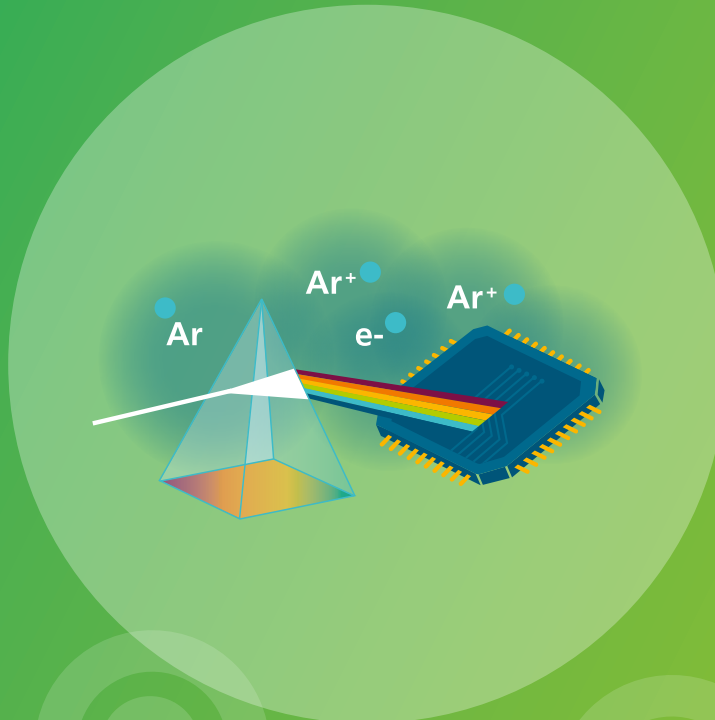
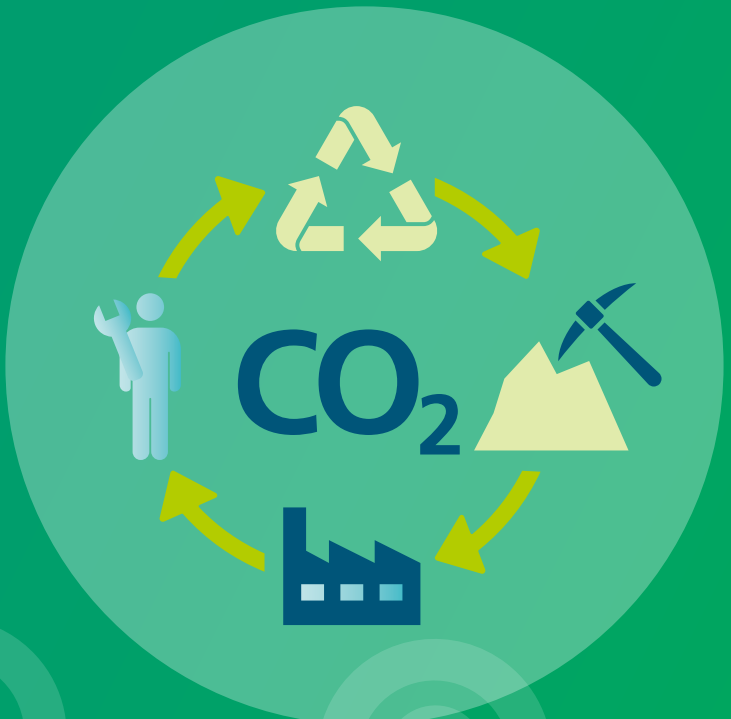
with precision

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Our
expertise
along the entire process chain



Sustainable battery and hydrogen systems

Focus on the circular economy – for the energy of tomorrow

What were the department's highlights during the reporting year?

"The department 'Sustainable Battery and Hydrogen Systems' is dedicated to the holistic design of sustainable battery and hydrogen technologies. This is clearly reflected in the successfully completed projects: the circular economy project 'HVBatCycle' for high-voltage batteries and 'ST2P' (Stack-to-Piece) as part of the National Action Plan for Fuel Cell Production (H2GO). Central to both projects was the sustainable circular management of energy storage and conversion systems as the foundation for a holistic and future-proof energy supply. The continuing education program "think GREEN, act SMART" complements these activities by providing an in-depth exploration into the principles of sustainability, particularly in the context of life cycle assessments and their integration into corporate structures."

Which topics and challenges will be particularly important for your department in the coming years?

"Against the backdrop of climate change and growing resource scarcity, circular economy continues to gain importance, as it enables the efficient use of valuable materials while minimizing environmental impact. The department is therefore specifically expanding its research infrastructure in the field of recycling to develop innovative approaches to material recovery and components reuse, particularly within the hydrogen economy. At the same time, the focus remains on advancing resource-efficient processes and technologies that enable the sustainable production and utilization of energy storage devices and systems."

What is the particular strength of your department, and what contribution do you make to the development of new key technologies?

"The department's particular strength lies in the close interdisciplinary integration of material and process development for battery and hydrogen technologies, accompanied by a holistic life cycle engineering approach. This combination enables sustainable product and process design along the entire value chain. Drawing on our deep technical expertise, we support our customers and partners – through direct collaboration as well as practice-oriented, continuously evolving training programs – in implementing sustainable processes and developing environmentally friendly products that meet both market demands and regulatory requirements."

Camera-based, automated analysis of the condition of disassembled components, using a bipolar plate as an example.



Your benefits at a glance

- Customized, application-oriented training programs on sustainability, hydrogen technologies, and the circular economy of batteries
- Development of sustainable material, production, and recycling processes for battery and hydrogen systems
- Comprehensive analysis of current and future processes, with customized life-cycle management strategies
- Automated assembly and disassembly processes for fuel cell stacks, batteries, and vehicles
- Energy system modeling and techno-economic evaluation of manufacturing systems and hydrogen supply chains

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From research

Ammonia as the key to hydrogen supply

Techno-economic assessment of land-use scenarios and infrastructure options

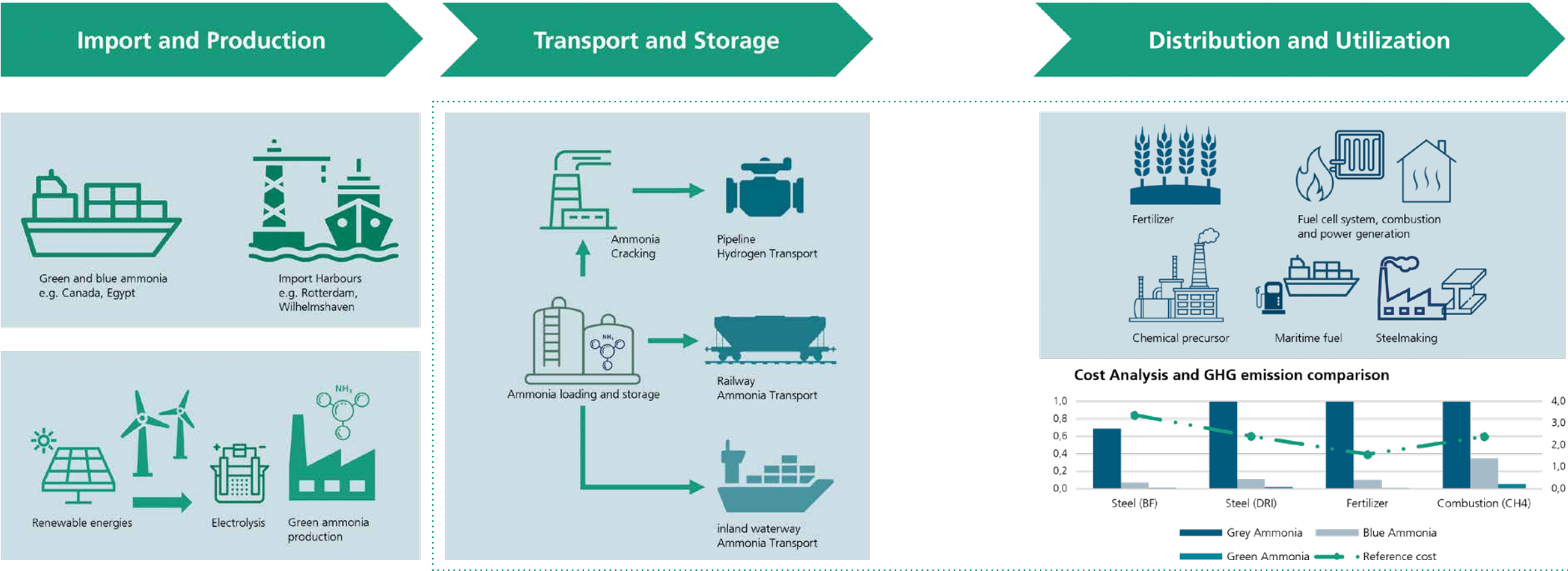
The energy transition requires large quantities of climate-friendly hydrogen. In Germany, however, electrolysis capacity, storage, and transport infrastructure are limited, making imports necessary. It remains unclear which supply options make the most sense in specific scenarios – whether pipeline gas, expanding local electrolysis capacity, or ammonia as an energy carrier.

The energy transition requires large quantities of climate-friendly hydrogen. In Germany, however, electrolysis capacity, storage facilities, and transport infrastructure are limited, making imports necessary. It remains unclear which supply options make the most sense in specific scenarios – whether pipeline gas, expanding local electrolysis capacity, or ammonia as an energy carrier.

ammonia and other derivatives. The unique feature of this approach lies in the close integration of current market data with process engineering, resulting in realistic and robust scenarios.

The results provide companies, energy suppliers, and policymakers with a sound basis for decision-making regarding investments in terminals, electrolysis plants, and grid infrastructure. At the same time, they contribute to achieving climate goals cost-effectively, reducing price risks, and supporting the targeted ramp-up of a sustainable hydrogen economy – with added value for the economy and society.

Fraunhofer IST is therefore investigating ammonia as a hydrogen carrier specifically for Lower Saxony. Using regionally detailed techno-economic models, various utilization pathways are analyzed and compared – ranging from imports and cracking to storage-based direct use and co-firing with



Scope of the work

The project analyzes domestic value chain steps and evaluates the systemic application potential of green ammonia in various sectors from a techno-economic perspective, with a particular focus on storage and transport systems for direct use.



The project

The project was developed as part of the research program “Transformation des Energiesystems Niedersachsen” (TEN. efzn; engl. Transformation of the Lower Saxony Energy System) at the Energy Research Centre of Lower Saxony (efzn). It is funded by zukunft.niedersachsen, the joint research funding program of the Niedersächsische Ministerium für Wissenschaft und Kultur (engl. Lower Saxony Ministry of Science and Culture) and the VolkswagenStiftung.

Project name

Transformation des Energiesystems
Niedersachsen – Landesgraduiertenkolleg “Wasserstoff
und Wasserstoffderivat Ammoniak”
(engl. Transformation of the Energy System
Lower Saxony – State Graduate Program “Hydrogen
and Hydrogen Derivative Ammonia”)

Project duration

01.10.2024 – 30.09.2029

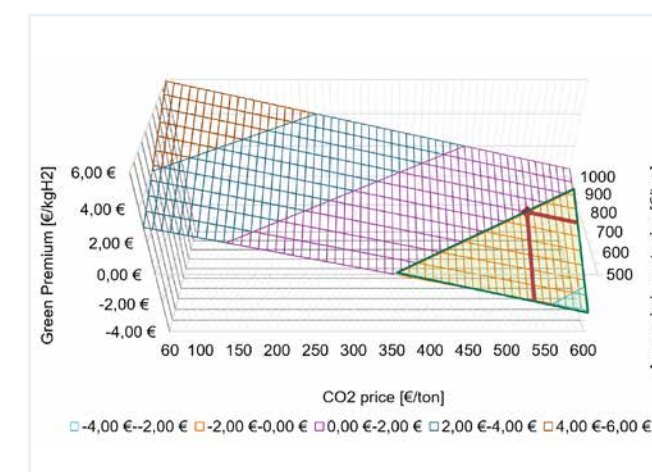
Project partner

Energy Research Centre of Lower Saxon (efzn)

Funding number

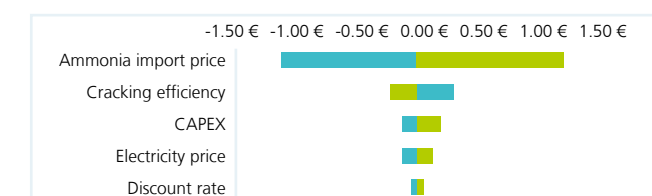
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The green premium of green hydrogen

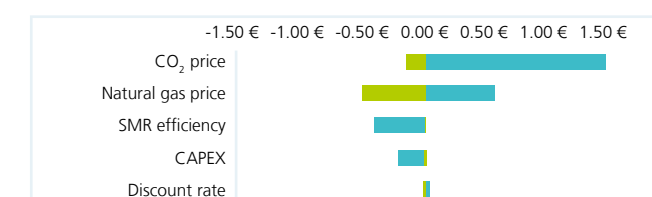


Comparison of hydrogen production costs and their sensitivity for green hydrogen produced via ammonia cracking versus gray hydrogen produced via steam methane reforming.

Sensitivity analysis of LOCH for cracking



Sensitivity analysis of LCOH for SMR plant



Contact

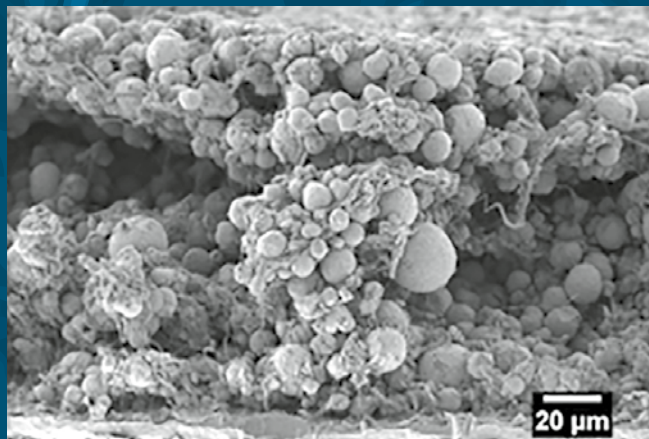
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From research

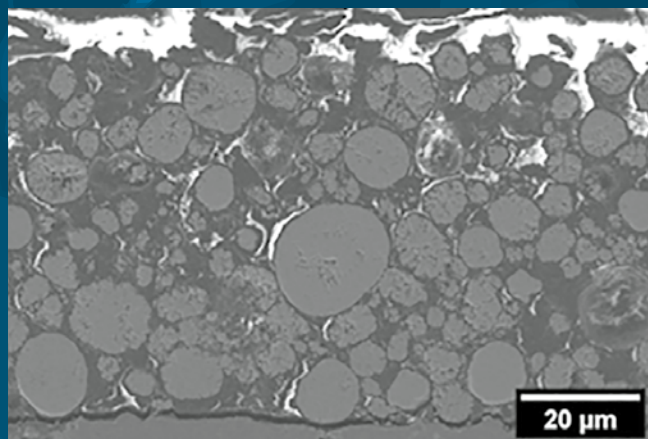
Insights into structure, porosity, and particle contact

Cross-sectional analysis of particulate layers

Particle-based coatings play an important role in numerous applications – from titanium dioxide-based wall paints to biocompatible implant coatings and active materials on metal foils in batteries. However, key questions regarding their internal structure – such as particle contact or porosity – can only be answered through destructive analysis. The challenge in materials analysis is to preserve the coating properties during preparation so that they can subsequently be reliably characterized.



Fracture surface of a particulate layer with visible binder filaments. The layer has fractured uncontrollably due to cohesive failure and exhibits an inhomogeneous fracture structure. However, the binder filaments are clearly visible.



Metallurgical cross-section of a particulate layer. The embedding medium has partially penetrated the pore system. Nevertheless, the particle morphology is clearly visible.

When standard methods reach their limits

At Fraunhofer IST, various sample preparation methods are used. The simplest method, fracturing, often yields good results for compact thin films. However, with particulate layers, this frequently results in rough fracture edges where particles are torn from the layer. Determining the film thickness or obtaining information on porosity is thus hardly possible. Nevertheless, the method can provide relevant information, such as regarding the binder materials between the particles.

Strategic planning of sample preparation

A metallographic cross-section often provides better insights. This technique is primarily used in conjunction with metallic materials. Particulate layers can be embedded and ground very well, depending on the particle size. However, hot embedding under pressure in particular can alter the porosity of the layer. Additionally, embedding material can be introduced into the pore system during grinding, thereby damaging fine structures in the nanometer range. Despite these limitations, the method offers valuable insights with relatively little effort.

Precision through ion beam technology

Nearly perfect cross-sections of a particulate layer can be achieved by using ion beams as a cutting tool. Focused ion beams in a scanning electron microscope enable precise cuts in layers up to about 100 μm thick. For thicker layers, argon ion beams are used, which allow cuts in the millimeter range. The method produces precise and smooth cut surfaces but requires careful handling of energy-induced changes in sensitive materials and potential artifacts. When used correctly, ion beam cutting is an extremely powerful method.

The right method for the right research question

The various preparation methods have specific advantages and disadvantages, with the effort required increasing as quality improves. The choice of the appropriate method depends crucially on the research question. Fraunhofer IST supports the development of the optimal strategy for every analytical challenge and the achievement of reliable results.

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Sustainability management and Life Cycle Engineering

Practical sustainability solutions for the German industry

What were the department's highlights during the reporting year?

"For the 'Sustainability management and Life Cycle Engineering' department, 2025 was marked by intensive scientific networking and the strategic expansion of partnerships. Successful joint research projects with the Technical University of Braunschweig, such as 'TranSensus LCA', as well as increased cross-departmental collaboration within Fraunhofer IST laid the foundation for promising collaborations. In addition, strategic partnerships with regional stakeholders, including within the framework of the Open Hybrid LabFactory in Wolfsburg, were further deepened. With the launch of the 'LCE Platform' and projects with an increased focus on sustainable, resilient supply chains such as 'SuSteelAG', we were able to ensure that we are optimally positioned, both technically and methodologically, with regard to important future topics. Last but not least, we are pleased that, despite challenging economic times, we were able to make a positive contribution to the sustainability of the German industrial landscape through a successfully concluded collaboration with a large medium-sized company focused on 'cost-effective decarbonization'."

What is the particular strength of your department, and what contribution do you make to the development of new key technologies?

"Our department is distinguished by its close ties to industry and its in-depth expertise in environmental and economic assessment methods, which enable us to make sustainability measurable for our clients while taking the business perspective into account. A key unique selling point is the derivation and prioritization of individual decarbonization measures using marginal abatement cost curves. This methodological expertise was successfully applied in several industrial projects in 2025 to develop practical, economically viable sustainability strategies for our clients – in line with the Fraunhofer model of applied research."

Which topics and challenges will be particularly important for your department in the coming years?

"Against the backdrop of increasingly challenging economic conditions and declining demand for green business models, the development of cost-effective decarbonization strategies for German industry is becoming increasingly important. This is where we come in, by identifying tailored measures and combining environmental impact with a positive business case. In light of the future demand for cost-effective sustainability measures, we are developing the 'LCE Platform' as an interface through which we can strategically pool expertise and resources. Looking ahead, this will enable us to further scale sustainable solutions and expand them to other key areas, particularly resilient and sustainable supply chains. Strong networking with the regional research landscape will remain a key success factor in the future as well."

Your benefits at a glance

- Identification of customized, cost-effective sustainability strategies tailored to companies and industries
- Support in implementing sustainability goals and obtaining relevant environmental certifications
- Development of customized assessment tools for companies to enable comprehensive product and process optimization
- Support in calculating individual environmental impacts, such as the carbon footprint or water footprint
- Offering training and learning programs on sustainability-related topics such as life cycle engineering or the circular economy

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SuSteelAG

The SuSteelAG project is developing an innovative process for producing sustainable steel.



From research

“SuSteelAG” as the key to a climate-neutral industry

Green steel for Germany and Australia

The steel industry accounts for about seven percent of global CO₂ emissions, making it a key focus of industrial decarbonization. The “SuSteelAG” project addresses this very issue by developing an innovative, climate-friendly alternative to fossil-fuel-based steel production – from iron ore mining all the way to the finished steel product.

Climate-friendly steel production – how does it work?

A significant part of CO₂ emissions in steel production comes from iron smelting. An alternative to the traditional blast furnace process is a method known as direct reduction, in which lump iron ore is exposed to a reducing gas and converted into iron without the use of coke.

While natural gas has been the primary fuel used for this process to date, hydrogen-based solutions are gaining increasing importance because they can significantly reduce emissions. One challenge, however, is that direct reduction has so far required iron ore pellets made from particularly high-quality ores. Their production involves additional effort, emissions, and costs.

The solution: Hydrogen-based direct reduction in a rotary kiln

As part of the “SuSteelAG” project, an innovative technology is being investigated and prepared for large-scale industrial application: hydrogen-based direct reduction in a rotary kiln. This process will make it possible to economically utilize even low-grade fine ores in the future. At the same time, processing costs are significantly reduced – and with them, the associated emissions and expenses. Fraunhofer IST contributes its expertise in holistic sustainability assessment and helps systematically integrate ecological and economic aspects. The goal is to develop practical solutions for industry that help resolve the conflict between economic efficiency and environmental protection.

Limited market for green steel

Much of the low-emission steel available today is based on recycling. In this process, steel scrap is processed and then melted down using renewable energy to produce high-quality secondary material. However, the availability of this resource is limited: scrap metal accumulates gradually due to the long service life of the corresponding products, while the demand for steel is continuously increasing due to the growing global population and rising prosperity. For this reason, the development of new, low-emission, and cost-effective production routes for primary steel is of central importance.

Achieving goals through strategic partnerships

The SuSteelAG project consortium covers the entire steel production value chain and brings together extensive expertise across all relevant process steps. The continued German-Australian partnership has the potential to generate significant long-term added value. Given the limited availability of raw materials, Australia is a strategically important partner for the German (steel) industry. Australia, in turn, benefits from cooperation with Germany as a technology hub through the exchange of knowledge and the development of potential new raw material markets.

The project

SuSteelAG – Sustainable Steel from Australia and Germany is funded by the German Federal Ministry of Research, Technology and Space (BMFTR).

Grant number
03SF0777G

Project duration
01.01.2025 – 31.12.2027

Project partners

- Bundesanstalt für Materialforschung und -prüfung
- Salzgitter Mannesmann Forschung GmbH
- TS Group Elino
- Hylron GmbH
- Fraunhofer Institute for Ceramic Technologies and Systems IKTS
- RWTH Aachen University
- Advanced Mineral Processing Technologies (AMR)
- Heidelberg Manufacturing Deutschland GmbH
- HANSAPORT
- Fortescue Metal Group (FMG)

With funding from the:



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Circular products and processes

Innovative surface technology as the key to the circular economy

What were the department's highlights during the reporting year?

"In the 'Circular Products and Processes' department, we focus on innovative recycling and reprocessing technologies for complex materials. A major milestone was the successful commissioning of a microwave plasma system for the targeted separation of carbon fibers and the polymer matrix in CFRP components. In the field of plastics, the efficient removal of paint from components using laser and flash-light methods was demonstrated. In addition, studies on back-injected wood veneers showed that bio-based protective coatings significantly improve the recyclability of composites compared to conventional paint systems."

What is your department's particular strength, and what role do you play in the development of new key technologies?

"We develop sustainable, practical surface technologies across the entire product lifecycle – from automated remanufacturing processes and functional coatings to the recycling of composite materials. Production-oriented facilities – ranging from injection molding to surface functionalization and coating – along with comprehensive analytical capabilities enable us to develop innovative solutions under realistic conditions. Our customers benefit from the efficient use of secondary materials and renewable raw materials, extended service lives, and environmentally friendly end-of-life strategies for their products."

Plasma treatment can condition the surfaces of recycled materials – which are typically non-uniform and, in some cases, difficult to process further – in such a way that subsequent processes, such as bonding or painting, become feasible again.

What issues and challenges will be particularly important for your department in the coming years?

"Durable bio-based and recycled materials will continue to grow in importance – not least due to regulatory requirements. We will therefore intensify our efforts, in particular, to recycle complex composite materials. Pyrolysis processes, targeted debonding solutions, and innovative coating systems play a key role in improving the quality of recycled materials. In addition, we are developing automated cleaning and repair processes to extend the service life of components – e.g., in vehicle interiors – and to provide high-quality components for the secondary market. To this end, a robot-assisted cleaning and repair system on autonomous transport systems is being developed at Fraunhofer CCEM in Wolfsburg."



Your benefits at a glance

- Plasma-based recycling processes for complex composite components
- Automated systems for cleaning, treatment, and functionalization
- Sustainable materials and surfaces for interior and exterior components
- COAD®-process for the targeted control of adhesion and bonding
- Comprehensive analytics for evaluating surface and material properties

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From research

COAD®: Sustainable plasma coating for controlled adhesion

Reliable adhesion is a key requirement for modern industrial products – especially for components subjected to high mechanical and thermal stresses. At the same time, the demand for sustainable, solvent-free production processes is growing. The COAD®-process developed by Fraunhofer IST offers an innovative solution for targeted and environmentally friendly adhesion optimization.

The COAD® process combines cleaning, activation, and functional coating in a fully automated, dry plasma process.



The VacuTEC 8080 is a low-pressure plasma system manufactured by TanteC that was specifically tailored to the proprietary COAD® process in collaboration with Fraunhofer IST. Since the completion of this enhancement, it has been available on the market under the name “Designed for COntrollable ADhesion.” The system is installed at the Fraunhofer CCEM in the Open Hybrid LabFactory in Wolfsburg.

Outlook: Optimization, emissions control, and material expansion

As the project progresses, the prototype plant will be commissioned and extensively tested in order to continuously optimize process control. The focus here is in particular on the neutralization of toxic process gases such as hydrofluoric acid, as well as on determining and minimizing the required energy input. In addition, there are plans to integrate other composite materials such as glass-fiber- or carbon-fiber-reinforced polymers, as well as electrical and electronic components, into the recycling process in the future.

Reliable adhesion in the tightest of spaces

In high-precision applications such as bicycle hub gears, sealing systems must function reliably over the long term. Conventional methods for improving adhesion reach their limits in these applications, as they are often solvent-based, energy-intensive, or unsuitable for the specific geometry. In particular, the adhesion of liquid sealants to metal surfaces poses a major challenge.

COAD® – Controlled adhesion via plasma

The COAD® process is a dry plasma process developed at Fraunhofer IST that combines cleaning, activation, and coating in a single automated process. A nanometer-thin, highly reactive layer specifically improves adhesion between different materials – all without solvents or additional drying steps.

Added value for industry and the environment

The COAD® process can be flexibly adapted to different materials, geometries, and production volumes and cost-effectively integrated into existing production lines. The result: higher product quality, stable processes, reduced CO₂ emissions, and new industrial applications for functional plasma coatings – a win for companies, users, and the environment alike.

Scaling and new areas of application

The COAD® process is continuously being refined and adapted for use in new industries – from mobility and medical engineering to electronics manufacturing. The goal is to establish controlled adhesion as the industry standard for sustainable, high-performance surfaces.

The project

The COAD® process was developed at Fraunhofer IST and registered as a trademark. The technology was successfully integrated into an industrial plasma system from TanteC A/S, licensed, and transferred to Rohloff AG. It is marketed worldwide under the name VacuTEC® – Designed for Controlled Adhesion.

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Medical technology and pharmaceutical systems

Where interfaces enable medical applications

What were the department's highlights during the reporting year?

"In our department, we investigate how surfaces and materials can be modified for medical engineering or pharmaceutical applications. Our focus is on how interfaces can be altered to specifically control adhesion – for example, through adhesion-promoting or anti-adhesive coatings. A highlight last year was the use of a plasma source for in-situ coating in 3D printing, which we were able to test on-site at a project partner's facility. This allows the printed substrates to be coated directly during the manufacturing process, resulting in homogeneous layer distribution even for complex or very small structures."

What issues and challenges will be particularly important for your department in the coming years?

"The aging population will pose major challenges for the healthcare system in the coming years. This calls for reliable yet cost-effective solutions for diagnostics, therapy, and drug production. Together with our partners, we are conducting research to improve production processes for particulate pharmaceutical systems, develop sustainable packaging solutions for modern drugs, and design medical devices for reliable administration or diagnostics. Coating and surface technology can make valuable contributions in this regard."

What is your department's particular strength, and what role do you play in the development of new key technologies?

"Our particular strength lies in the combination of a broad coating portfolio and application-oriented evaluation of the solutions we develop. We utilize nearly the entire range of coating technologies available at Fraunhofer IST to optimally address our customers' needs. Our most common applications include the coating of particles, primary packaging materials, and medical devices, as well as the functional modification of equipment surfaces and production tools. At the same time, we develop customer-specific testing and evaluation methods to assess our coatings in a practical, application-oriented manner. Through close collaboration with the Center for Pharmaceutical Process Engineering (PVZ) at the Technical University of Braunschweig, we cover the entire research chain from fundamental development to full-scale application in industrial production."



Your benefits at a glance

- Adhesion-controlling and anti-adhesive coatings for medical and pharmaceutical applications
- Development of application-oriented test and evaluation methods for characterizing adhesion phenomena at interfaces
- Control of interfacial properties on packaging materials, devices, production equipment, and tool surfaces
- Functionalization and coating of particles for pharmaceutical systems
- Implementation across the entire research chain – from material development to industrial application

Sample preparation for the targeted adjustment and analysis of interfacial properties.

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*In-situ plasma coating during 3D printing:
A plasma ring source developed at
Fraunhofer IST generates reactive bonding
sites on the polymer surface directly during
the extrusion process.*

From research

Efficient purification of complex biomolecules

Custom-designed chemically reactive surfaces produced via 3D printing

Modern therapies require the efficient purification and selection of cells and proteins from complex solutions such as blood. In practice, bead-based chromatography columns using agarose are frequently used for this purpose. However, these are relatively expensive, pressure-sensitive, and limit potential throughput due to their material properties. For future biotechnological and medical applications, therefore, more cost-effective, robust, and at the same time more efficient alternatives are needed.

In-situ plasma functionalization directly during the extrusion process

This is where the “StrepTag3D” project comes in. The goal is to use 3D printing to create cost-effective alternatives. A key challenge is that polymer surfaces are initially inert with respect to specific functionalization. To address this, Fraunhofer IST has developed a plasma source that can be directly integrated into the extrusion process of an FDM printer. This allows reactive binding sites to be created on the polymer surface during the printing process using a solvent-free method, to which selective capture molecules can be attached.

New perspectives for biotechnological purification systems

In combination with the 3D-printed structures developed by BellaSeno and the purification protocols developed by IBA Lifesciences, the technology opens up new possibilities for purification, for example in biotechnological processes. In the future, these additively manufactured and functionalized structures will also enable more cost-effective and sustainable production of purification systems for therapeutic applications.

The project

StrepTag-mediated chromatography on 3D-printed matrices

Project duration

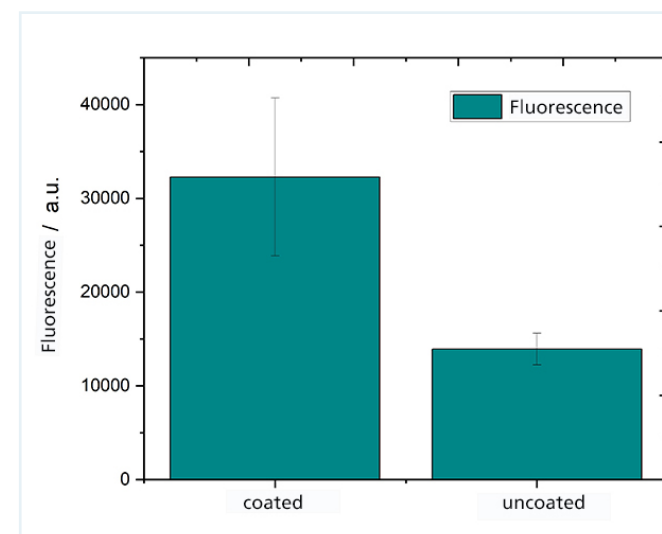
01.01.2024 – 31.03.2026

Funding body

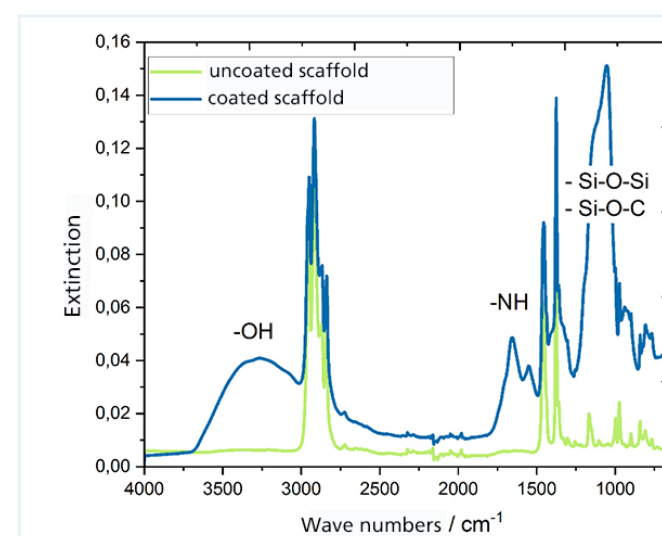
Federal Ministry of Research, Technology and Space

Grant number

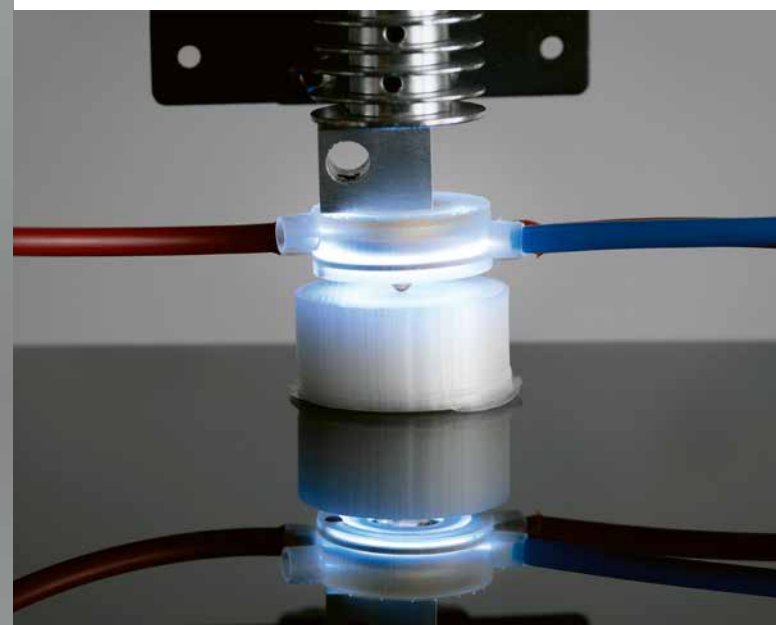
02P23K002



Detection of chemically reactive functional groups on a scaffold that was coated during the printing process.



Detection of characteristic absorption bands in plasma-deposited coatings from 3D printing using FTIR-ATR spectroscopy.



Ring plasma source for surface activation of 3D-printed scaffolds synchronized with the printing process. Ideal for preparing the surface for functional or biochemical coatings.

Contact

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Your benefits at a glance

- High-precision optical coatings for maximum performance of your components
- Innovative production processes to optimize efficiency and quality
- State-of-the-art simulation methods to shorten development times
- Coating processes for excellent coating quality, high reproducibility, and long service life of optical components
- International networking, e.g., through the research and innovation platform in Taiwan, opens up access to new markets and technologies
- Support from simulation through development to industrial implementation
- Future-proof solutions for demanding applications in the optics industry

Optical and electronic systems

Precision coatings for future technologies

What were the department's highlights during the reporting year?

"During the reporting year, the 'Optical and Electronic Systems' department achieved significant successes with production systems for precision optical coatings. The established EOSS® system and the OPTAX upgrade confirmed their performance capabilities; a particular highlight was winning the Manufacturing Contest at the OIC Conference (Optical Interference Coatings Conference). Our Fraunhofer innovation platform for Surface and Production Engineering for Optical and Electrical Systems at Feng Chia University (FIP-SPE@FCU) in Taiwan developed very dynamically and initiated its first projects. In addition, we were able to carry out exciting development projects, including the ESA project "Infrared Coatings" as well as electrochromically switchable radiator coatings for future space applications."

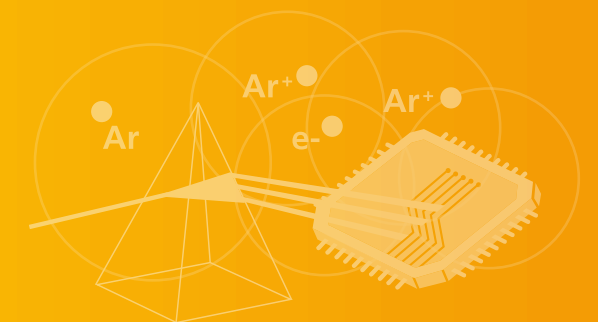
What issues and challenges will be particularly important for your department in the coming years?

"In the coming years, space and security issues in particular will continue to gain importance, such as infrared-based applications for surveillance and communication. At the same time, sustainability and energy supply remain key drivers, particularly through coating and system solutions for hydrogen technologies. Furthermore, we are expanding AI-supported modeling as part of the FIP in Taiwan and consistently developing our production technology toward optics and semiconductor manufacturing."

What is your department's particular strength, and what contribution do you make to the development of new key technologies?

"Our particular strength lies in customized thin-film solutions, which we consistently design with the application in mind while keeping the overall system in view – from hydrogen technologies to magnetic, optoelectronic, and precision optical systems. With our internationally leading PIC-MC plasma simulation, which is used by both research and industry, and a highly qualified team, we translate complex coating processes into practical, reliable, and efficient key technologies, thereby creating direct added value and sustainable competitive advantages for our partners."

The infrared spectrum is relevant for many new applications, ranging from Earth observation to defense. The sputtered coatings shown here, made from various materials, promise outstanding optical performance and improved environmental stability, which have been validated in various standardized tests.



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From research

Innovative fluorescence analysis system provides real-time data for resource-efficient management

Precise plant analyses for sustainable agriculture



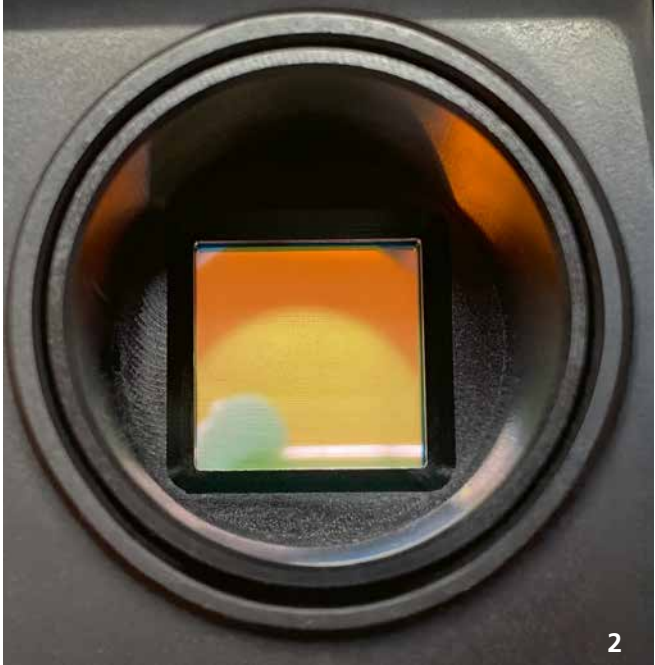
Agricultural businesses are under intense pressure: they are expected to increase yields while reducing their use of fertilizers and pesticides and complying with environmental regulations. Climate change and extreme weather events are further exacerbating these challenges. Real-time monitoring of crop health is essential for precision farming approaches. While traditional laboratory analyses provide accurate results, they are costly, time-consuming, and cover only small, isolated areas.

Visual assessments and simple optical indices derived from camera or satellite data, on the other hand, allow only rough estimates of the actual stress level. Early nutrient deficiencies, drought stress, or the onset of disease often remain undetected until yield or quality losses have already occurred. For truly precise and sustainable management, new measurement methods are therefore needed that are cost-effective, robust, and can be used directly in the field, and that reliably capture the complex interactions between plants and soil.

Real-time fluorescence-based analysis

As part of the quantiFARM joint research project, Fraunhofer IST is developing a novel fluorescence imaging analysis system that captures spectral signatures of plants and soil, enabling conclusions to be drawn about metabolic processes, stress responses, and nutrient supply.

The fluorescence analysis system is being tested on sugar beets directly in the field.



The Fraunhofer IST mosaic filter is at the heart of the fluorescence imaging system.

A key element of the system is a specially designed, microstructured mosaic filter, which serves as the central optical component for plant analysis. Narrowband interference filters form a mosaic of numerous spectral channels on a single substrate. These channels are precisely tuned to the sun-induced fluorescence related to photosynthesis. What sets the Fraunhofer IST's development apart is the combination of precise spectral channels with microstructured manufacturing. This keeps the system compact, cost-effective, and easily integrable directly into cameras for agricultural applications. Several prototypes of the fluorescence analysis system are being tested in the field in collaboration with project partners to enable its widespread deployment.

Efficient, precise, sustainable

The quantiFARM sensor enables quick, non-destructive, and cost-effective measurement of plant and soil characteristics directly in the field. Farmers gain a reliable data foundation for managing fertilization, irrigation, and crop protection on a sub-plot-specific and evidence-based basis.



This enables a reduction in input costs, minimizes yield risks, and stabilizes product quality. For breeders and machinery manufacturers, new digital services and business models based on high-resolution condition data are opening up. On a societal level, the technology helps reduce greenhouse gas emissions and minimize the runoff of crop protection products into soil and waterways.

The project

Quantitative Optical Differential Diagnostics for Environmental Protection and Sustainability in Agriculture

Project partners

- KWS SAAT SE & Co. KG
- JB Hyperspectral Devices GmbH
- asphericon GmbH
- MIOPAS GmbH
- Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)
- Fraunhofer Heinrich Hertz Institute HHI

Project duration

01.11.2024 – 31.10.2027

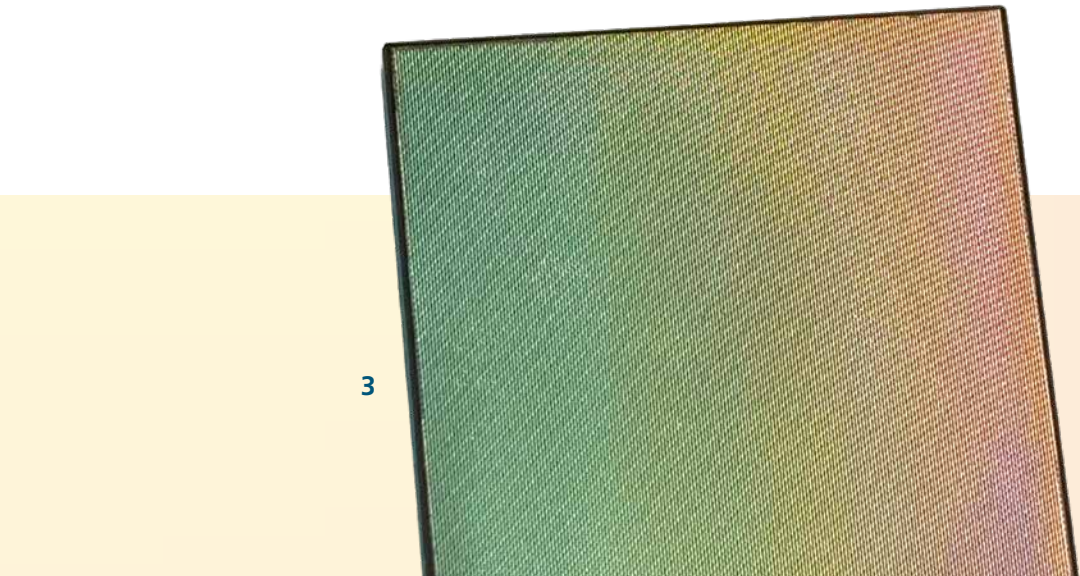
Funding body

Federal Ministry of Research, Technology and Space

Grant number

13N17096

Ultra-narrow bandpass filters (< 1 nm half-width) were integrated into a mosaic filter at Fraunhofer IST through several coating steps.



Contact

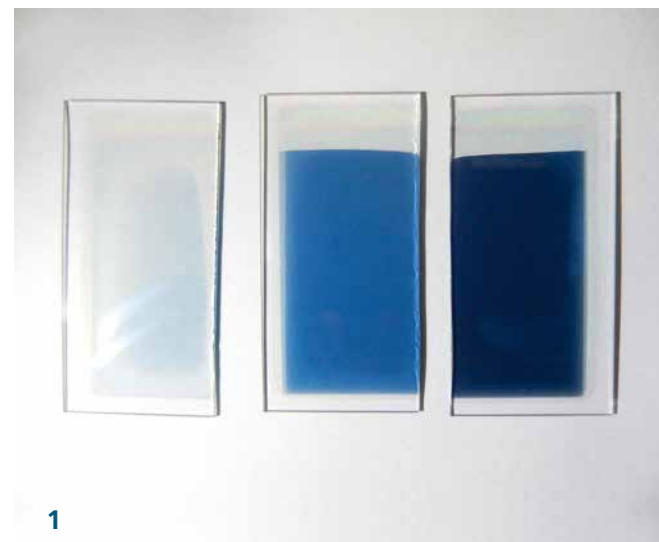
Dr. Philipp Farr
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From research

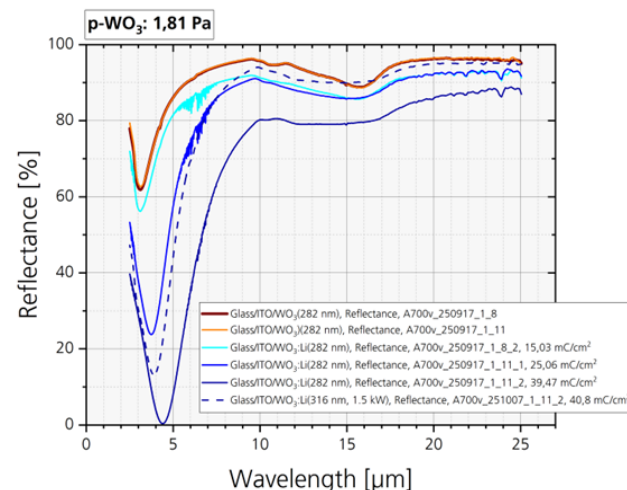
Advances in electrochromic emittance modulators

An alternative approach to satellite climate control

Extreme temperature differences prevail in space: On the sun-facing side, satellites can heat up to over +120 °C, while on the far side, temperatures can drop below -150 °C. Reliable thermal control is therefore crucial for the operation of space systems to ensure the reliable functioning of sensitive electronics and instruments. To date, mechanical shutters have often been used to regulate heat radiation. However, these systems increase weight and are prone to failure due to their moving parts. A promising alternative is switchable, electrochromic emittance modulators, which precisely control heat radiation and could make a decisive contribution to energy optimization in future satellites. The Fraunhofer IST is working on this technology as part of the ESA project “Electrochromic Coating for Radiators.”



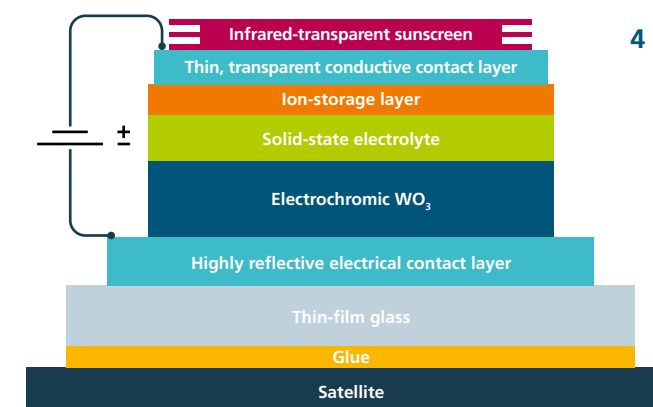
1 Tungsten oxide layers with increasing intercalation of lithium ions (15 to 39.5 mC/cm², from left to right).



2 Change in the infrared reflectance of a glass/ITO/WO₃ layered structure in the thermal infrared region as lithium-ion intercalation increases.



3 First prototype of an electrochromic emittance modulator; the dashed lines indicate the location of the respective contact layer.



4 Schematic diagram of the emittance modulator.

Electrochromic coatings enable controllable heat radiation

The approach is based on electrochromic, switchable tungsten oxide (WO₃). This material is known for its darkening in the visible light spectrum due to lithium intercalation (see Figure 1).

A similar, less well-known switching behavior also occurs in the thermal infrared wavelength range. This allows the reflectance of an underlying highly reflective, conductive layer to be specifically modified (see Figure 2): High infrared reflectance leads to lower heat radiation, and reduced reflectance leads to increased heat dissipation.

Thin-film design for efficient emittance modulators

For the emittance modulator, the electrochromic principle is applied to a multilayer structure. In this setup, lithium – controlled electrically – can be located either in the WO₃ or in an infrared-transparent ion storage layer. An upper contact layer ensures uniform application of the switching voltage while maintaining high transmission in the infrared range. For this purpose, Fraunhofer IST uses a special conductive oxide with low infrared absorption.

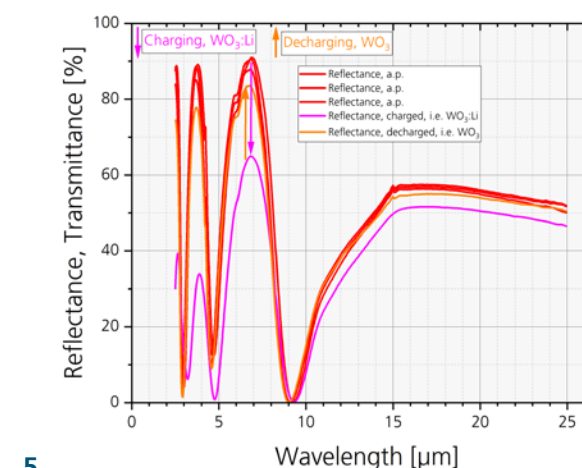


Outlook: Wider switching range for future applications

With an initial prototype, switching shifts of 51 and 22.5 percent have already been achieved in narrow spectral ranges centered around wavelengths of 4 and 7 μm (see Figure 5). In the future, the switchable range is to be expanded to approximately 5 to 25 μm, particularly at the peak of thermal infrared radiation at 10 μm. To this end, the layer thicknesses will be adjusted, and nickel oxide (NiO) will be used as a proven ion storage layer. In addition, lightweight thin-glass substrates and a solar reflector are planned, which will reduce heating by sunlight while allowing the relevant infrared light to pass through.

The project

As part of the “Electrochromic Coating for Radiators” project, Fraunhofer IST is developing electrochromic emittance modulators for satellite climate control. The project is funded by the European Space Agency (ESA).



5 Switching behavior of the first emittance modulator prototype.

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Your benefits at a glance

- Development of application-specific coatings for diamond- and silicon-based applications
- Cost-effective coating processes through large batch volumes and high-throughput processes
- Development and optimization of components for our coating technologies
- Coating-optimized design and material selection for diamond-coated tools
- Research and development of new cell concepts, e.g., perovskite-silicon tandem solar cells
- Material development and characterization for modern solar cells
- Technology transfer to industry for practical application and sustainable customer benefits

Diamond-based systems

Efficient, durable, and robust components for industrial applications

What were the department's highlights during the reporting year?

"With a focus on sustainability and digitalization, three highlights shaped the year: The modernization of our diamond coating system CVDiamond XXL with new PLC, measurement- and visualization-technology enables digitally supported process control. In addition, the joint research projects 'FreeTools' and 'SimVision' were launched, focusing on cobalt-free high-performance tools and AI-based surface inspection, respectively. A particular highlight was the 'Innovations for a Better Future' award from the Fraunhofer Future Foundation for our contribution to the 'PreCare' project. Using diamond-coated electrodes, the project enables the on-site production of disinfectants in modular healthcare platforms for remote regions."

What is your department's particular strength, and what contribution do you make to the development of new key technologies?

"The department combines an understanding of production engineering systems with in-house component development and a broad technology portfolio: hot-wire CVD for diamond- and silicon-based coatings, ALD and SALD processes, as well as optical evaluation and characterization methods – supplemented by digitally supported process control. This enables customized functional coatings for tools, mechanical seals, diamond electrodes, gas sensors, and electronics. Our customers benefit from longer-lasting components and systems that are more energy- and resource-efficient."

What issues and challenges will be particularly important for your department in the coming years?

"Increasing demands for resource efficiency, process reliability, quality, and scalability will shape our future work. We are continuing to develop diamond-based coatings for tools and components used in semiconductor manufacturing and are driving forward the research into diamond-coated, cobalt-free tools that substitute critical raw materials. For data-driven process control and quality assurance, we are establishing AI-supported optical evaluation based on synthetic image data. At the same time, using our innovative hybrid SALD system, we are enabling the high-throughput functionalization of silicon-based nanostructures through highly conformal ALD films for gas sensing, and are further expanding the field of sensor technology through the increased use of diamond-based coatings."



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"CVDiamond XXL" hot-filament CVD coating system for large-area diamond coating (up to 1,000 × 500 mm) as well as the coating of complex components and tools.

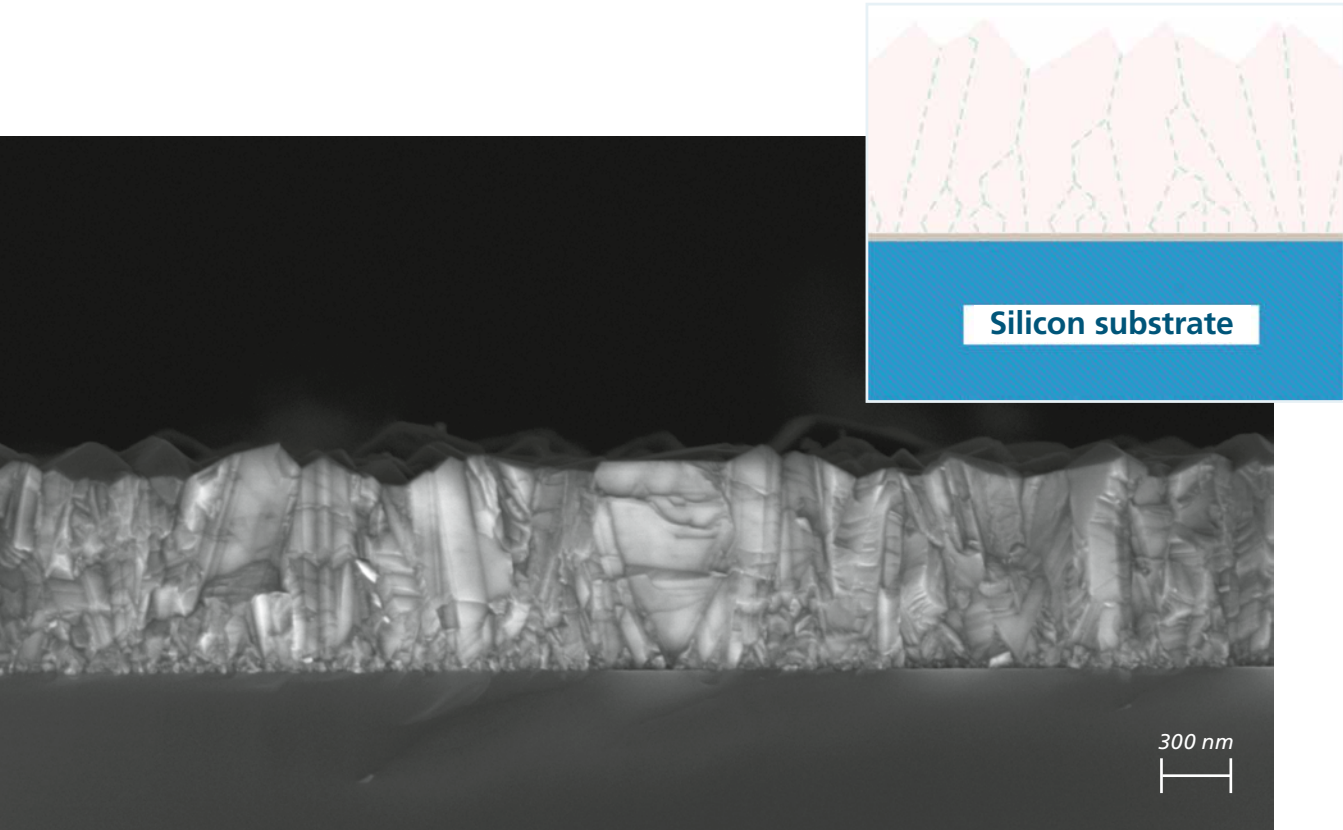
From research

Diamond in focus

Determination of optical constants of large-area diamond coatings

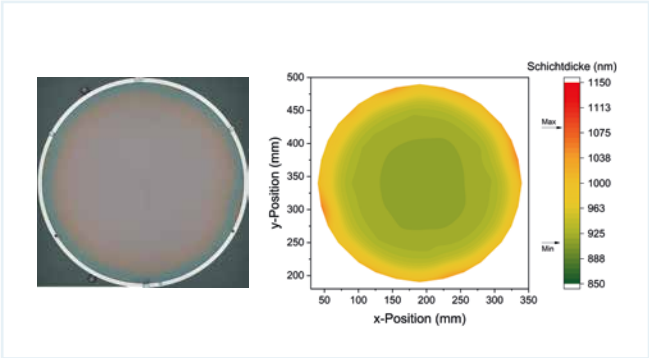
Limitations of conventional measurement methods for diamond coatings

The homogeneity of diamond coatings is a critical quality factor for numerous high-tech applications. In order to reliably evaluate and specifically optimize large-area coatings – for example, on silicon wafers – the complex refractive index of diamond must be known precisely over a broad wavelength range. However, determining these optical constants is challenging, as material inhomogeneities, surface roughness, and multilayer systems influence the measurement. Conventional methods are therefore only of limited use in addressing this challenge.



SEM image (left) and sketch (right) of a diamond film on a silicon substrate with a natural oxide layer. The grain size and roughness of the growing polycrystalline diamond film increase with the film thickness.

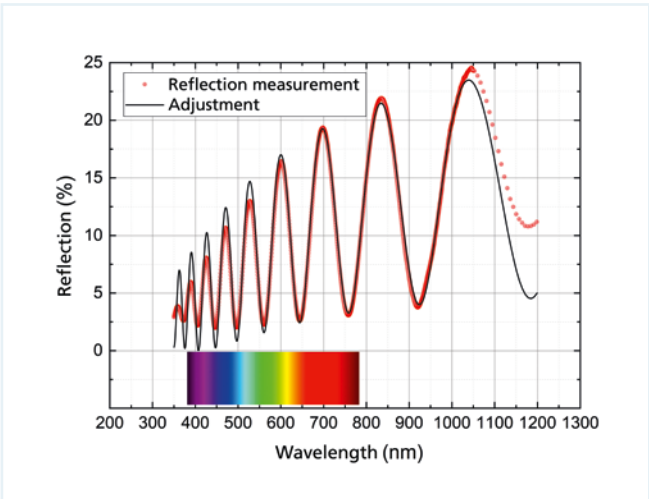
Semiprocessing



Comparison of a non-optimized (left) and an optimized coating process (right). In each case, a diamond-coated silicon wafer (300 mm) and the corresponding film thickness distribution (same film thickness scale for both wafers) are shown. In the non-optimized process (left), the film thickness ranges from a minimum of 913 nm to a maximum of 1081 nm; in the optimized process (right), it ranges from a minimum of 1013 nm to a maximum of 1059 nm. The greatest deviations occur at the wafer edges in both cases.

Holistic measurement approach through simultaneous data analysis

Fraunhofer IST combines spectral photometry with variable-angle spectroscopy (ellipsometry) and evaluates all measurement data using a global modeling method. This simultaneous analysis enables the precise determination of the dielectric function as well as relevant coating parameters of diamond. For this purpose, a specially developed multilayer model is used, which realistically describes the polycrystalline diamond layer, including its roughness, and integrates known optical material data. This combined, simultaneous fitting method represents a key unique selling point of Fraunhofer IST and allows for significantly greater accuracy compared to isolated measurements.



Example of a measured reflection spectrum in the wavelength range from 250 to 1200 nm with a fitted curve to determine the layer thickness and roughness. To illustrate the range perceivable by the human eye, a color bar showing the visible spectrum is also displayed.

Efficient characterization of large-area wafers

Once the optical dispersion of the diamond film has been determined, large-area substrates – such as wafers with a diameter of 300 mm – can be characterized quickly and efficiently using reflection mapping.

Customers benefit from significantly reduced measurement times, markedly improved process control, and the ability to specifically evaluate and optimize coating homogeneity even over large areas. This enable shigher production quality and high-performance, long-lasting diamond coatings in industry and research.

About the project

Internal pre-competitive research

Project duration

01.06.2025 – 30.09.2026

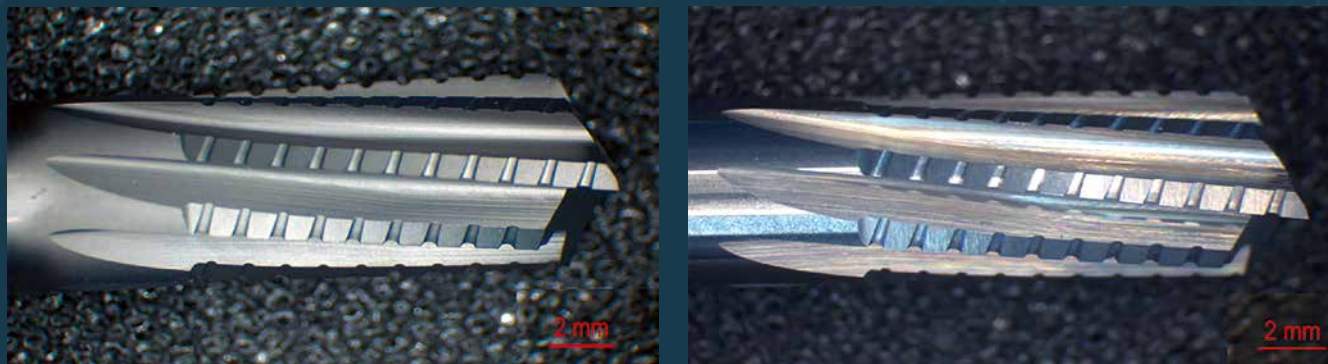
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Project SimVision

Automated visual inspection for production processes

Quality assurance for coated components and tools often involves complex visual inspection, during which a wide range of defects – such as geometric deviations or coating defects – are detected, thereby identifying defective parts. However, this process is not only time-consuming but also heavily dependent on the experience of the person carrying out the inspection. To make this predominantly manual inspection process more efficient and to automate it, the three Fraunhofer institutes – ITWM, IGD, and IST – are collaborating with TU Wien on the “SimVision” project to develop scalable approaches for AI-based visual inspection as well as methods for generating real and synthetic training data.



Light reflection on a coated (left) and an uncoated (right) tool surface.



Examples of various defects in coated tools: edge chipping on the base body and cutting edge (all three tools) and coating delamination (middle and right tools).

Defect types and complex surfaces

The coating of tools and components involves several process steps that can lead to significant changes in the visual appearance and reflectance behavior of the surfaces being inspected. In addition, a wide variety of defect patterns and defects on complex geometries must be detected. Reliable, AI-based visual inspection requires very extensive datasets, which in practice usually cannot be generated. Consequently, quality control has typically been performed through time-consuming manual visual inspections.

Inspection system for coated tools and components

At Fraunhofer IST, an automated inspection system is being developed that will initially be trained to detect defects in the diamond coating of cutting tools. Subsequently, the system will also be used to investigate the detection of tool wear and to explore additional applications for inspecting components and tools with PVD and CVD coatings in order to ensure production quality.

Automated inspection in production using rule-based training data

As part of the “SimVision” project, a flexible inspection system is being developed that automatically verifies surface quality at various stages of coating production. The foundation for this is a combined database that includes both photographic images of real sample sets and rule-based synthetic data generated using mathematical models of surface structure, potential defects, and component geometry. This diversity of photorealistic training data makes it possible to map a broad spectrum of potential surface conditions, thereby significantly improving the accuracy, flexibility, and cost-efficiency of the inspection system.

The project

“SimVision” is funded as a so-called ICON project (International Cooperation and Networking). As part of “SimVision,” researchers from the Fraunhofer Institutes for Industrial Mathematics ITWM, for Computer Graphics Research IGD, and for Surface Engineering and Thin Films IST are working in collaboration with TU Wien on the development of a scalable process chain to train artificial intelligence using real and synthetic data and transferring it to industrial applications.

Flexible quality inspection with AI using diamond tools as an example

Conventional AI-based methods reach their limits when surfaces are highly reflective, have varying textures, or feature geometrically complex shapes. In addition, varying surface topographies and lighting conditions make it difficult to reliably detect defects such as delamination, cracks, edge chipping, or wear. Using diamond coatings as an example, a physically based model of surfaces, defects, and light reflections is developed to generate realistic synthetic training data for pretreated and coated cutting tools.

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Tribology, corrosion and sensor technology

Smart surfaces for innovative products and processes

What were the department's highlights during the reporting year?

"During the reporting year, the department was able to further expand its specialist focus in a targeted manner. The integration of the Electroplating Group significantly strengthened the field of corrosion and corrosion protection within tribology. Furthermore, investments in new plant and equipment, including a high-temperature furnace and a boriding plant, have opened up additional possibilities in thermal and chemothermal materials treatment. This was complemented by the expansion of tribological testing and evaluation methods, thereby creating new opportunities for application-oriented research and industrial collaborations."

What is the particular strength of your department, and what contribution do you make to the development of new key technologies?

"Our customers are constantly on the lookout for new solutions to improve their products and production processes. Individual measures, such as applying a coating, are often no longer sufficient to meet rising technical requirements. A holistic approach to the surface, which takes equal account of the material, heat treatment, topography design and coating, offers significantly greater potential. To this end, Fraunhofer IST provides a broad spectrum of technologies and methods to enable the targeted design and comprehensive evaluation of the entire system."

Which topics and challenges will be particularly important for your department in the coming years?

"As Industry 4.0 progresses, the monitoring of products and production processes is becoming increasingly important. The department is addressing this development with customisable thin-film sensor technology, which enables the direct measurement of temperatures, forces, deformations or wear in high-stress areas. In addition to developing application-specific sensor designs, the focus in future will be particularly on issues of scalability and cost-effectiveness across the entire process chain. These are crucial for the successful transfer of this technology into industrial applications."



Your benefits at a glance

- Comprehensive system analysis
- Development of robust system solutions that take the entire production chain into account
- A broad technology portfolio and diversity of equipment for targeted surface design
- Extensive testing and analysis options for evaluating surfaces
- Application-specific thin-film sensor technology
- Digitalisation of surface processes

Sensory insert for plastic injection moulding.

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From research

Boride coatings for high-temperature applications



The new gas boriding plant at Fraunhofer IST uses diffusion treatments at temperatures of up to 1,050 °C to create boride boundary zones with exceptional technological properties.

In forming processes, extreme thermal stresses are among the greatest challenges for tools and components. High temperatures accelerate wear, promote adhesion, and significantly reduce service life. At Fraunhofer IST, boride surfaces are therefore being developed using PECVD or gas boriding processes, which are particularly suitable for complex geometries in tools and components for high-temperature applications. The resulting layers and boundary zones protect against abrasive wear, reduce adhesion, and thus contribute to extending tool life.

Challenges in industrial high-temperature forming

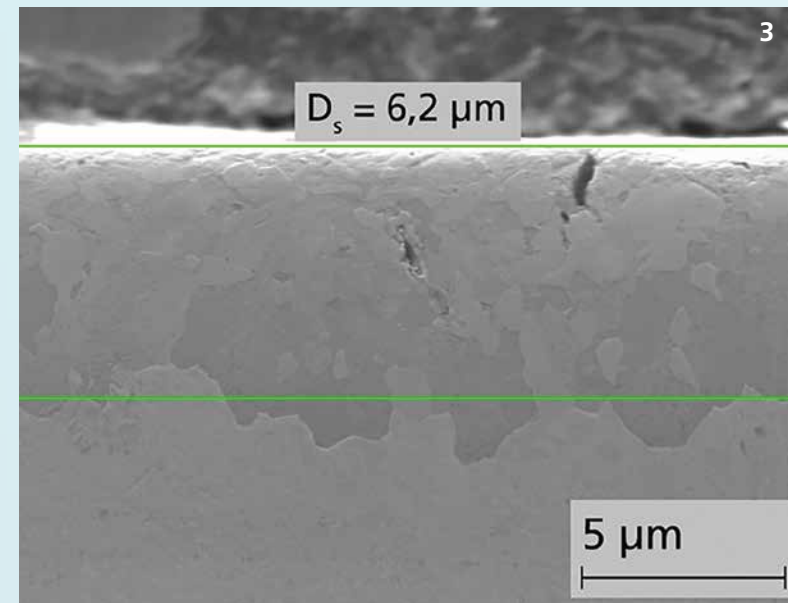
Typical industrial high-temperature applications include die forging of steel, extrusion of copper alloys, and forming of titanium alloys. These processes place extreme demands on tool surfaces: high thermal stability at process temperatures often reaching 1,000 °C or more, extreme hardness, and chemical inertness to reduce adhesion during forming operations. In addition to hot work steels, molybdenum alloys such as TZM or nickel-based alloys such as Nimonic® 75 are therefore used.

Innovative protection systems for tools

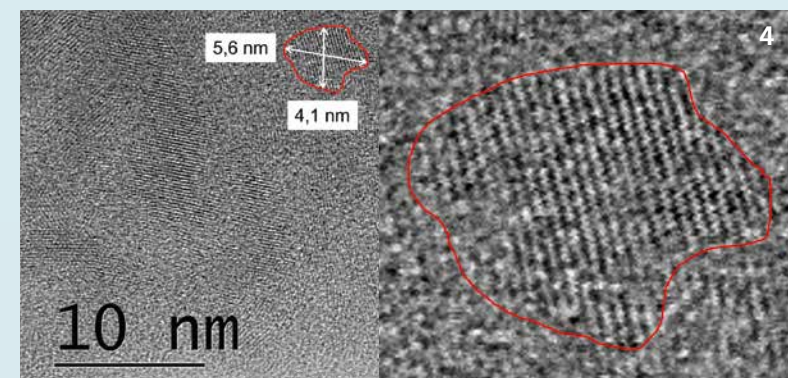
To meet these extreme thermal and tribological requirements, the Fraunhofer IST is pursuing two innovative approaches: On the one hand, plasma boriding produces boride phases through diffusion with excellent bonding to the base material and



The recently available high-temperature furnace enables investigations in the temperature range of up to 1,600 °C.



A cross-section of a TZM material following boriding and tempering.



Nanostructure investigations of a quinary boron-based Ti-Si-B-C-N layer show nanocrystalline phases in the TEM image (bright field mode).

hardness values of approx. 20 to 29 GPa, combined with high thermal stability (see Figure 3). On the other hand, quinary boride PACVD coatings (Ti-Si-B-C-N) form nanocomposites consisting of 4-7 nm nanocrystalline grains embedded in an amorphous matrix with hardnesses of up to 40 GPa and oxidation resistance up to 925 °C (see Figure 4).

Testing and qualification of surface solutions

In order to transfer these approaches to industrial applications, the developed solutions for the surfaces and edge zones of the forming tools and components are systematically qualified through various model tests and investigations. At pilot scale, a vacuum high-temperature furnace (up to 1,600 °C, < 10⁻⁵ mbar or, for example, under hydrogen atmosphere, see middle Figure) and a special tribometer are available for this purpose. Ring compression tests and production near forging trials are carried out in cooperation with the Institute of Forming Technology and Machines IFUM at Leibniz University Hannover and the Fraunhofer Institute for Machine Tools and Forming Technology IWU. Further evaluation takes place in industrial series investigations, e.g., within the framework of IGF projects.

Outlook: Scaling and new technologies

Based on the development and research results achieved to date, both approaches will be further developed at Fraunhofer IST in the future. From mid-2026, a new gas boriding plant (up to 1,050 °C) and a modernized PACVD system for the application of quinary Ti-Si-B-C-N systems will be available for this purpose. Please contact us for an application-specific wear protection solution under high-temperature conditions.

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The background is a dark teal color with a complex, glowing network of white lines and dots. The lines form a dense, interconnected web that curves across the frame, with some lines being thicker and more prominent than others. The dots are small and scattered throughout the network, some appearing as bright white points and others as fainter teal dots. The overall effect is a sense of dynamic connectivity and data flow.

The Fraunhofer IST

in networks

The Fraunhofer-Gesellschaft at a glance

The Fraunhofer-Gesellschaft, headquartered in Germany, is a leading organization for applied research. Since its founding as a nonprofit in 1949, Fraunhofer has held a unique position in the German research and innovation ecosystem. The research organization with more than 30,000 employees currently operates 74 institutes and independent research units throughout Germany. Fraunhofer plays a major role in innovation by focusing on cutting-edge technologies and transferring research results to industry to strengthen Germany as a business location and benefit society.

Its primary customer base comprises large and medium-sized companies, which utilize Fraunhofer's expertise to boost their competitiveness with new technologies. For years, Fraunhofer has been one of the most active patent applicants in Germany and Europe. Its international patent portfolio is the basis for technology transfer through research projects, spin-offs and licensing. Moreover, Fraunhofer addresses societal goals in key technology sectors through interdisciplinary and international partnerships in specific markets. Examples include solutions for microelectronics, artificial intelligence and quantum computing, healthcare, the circular economy, new materials, energy, critical infrastructure security, and defense.

Fraunhofer is a sought-after and established partner in publicly funded projects with industry partner involvement. It is also instrumental in strengthening Germany as a hub for innovation and business, ensuring its future viability. Its activities create jobs in Germany, boost the impact of investment on industry, give companies a competitive edge and foster public acceptance of advanced technologies. International partnerships with excellent research organizations and companies around the world directly connect the Fraunhofer-Gesellschaft with the most influential research communities and economic areas.

Fraunhofer's total annual budget amounts to 3.6 billion euros. Contract research, Fraunhofer's mainstay, generates 3.2 billion of this budget. Unlike other public research organizations, institutional funding from federal and state governments accounts for no more than one-third of its contract research budget, thus providing merely the base. Fraunhofer raises at least two-thirds of its contract research budget competitively from private-sector contracts and public project funding. Unlike organizations that are largely institutionally funded, the resulting strong incentive to develop business fosters entrepreneurial spirit, ensuring that Fraunhofer continuously develops solutions for current and future economic and societal needs. In 2025, industrial revenue accounted for 966 million euros.

Since highly motivated employees are the most important factor behind Fraunhofer's success, the research organization provides opportunities for independent, creative and goal-driven work. Fraunhofer facilitates career development in the research community and in industry with targeted programs for professional and personal development.

The Fraunhofer-Gesellschaft is a recognized nonprofit named after the scholar Joseph von Fraunhofer (1787–1826), who lived and worked in Munich. Joseph von Fraunhofer's inquisitiveness and business acumen enabled him to rise from a glass grinder to a scientific pioneer who, as an inventor and entrepreneur, turned ideas into marketable products and commercialized them. His innovativeness and market focus, as well as the belief that research and practical application go hand in hand, pervade the work of the Fraunhofer-Gesellschaft, which remains committed to his legacy.

Last updated: April 2026



Synergies through networking

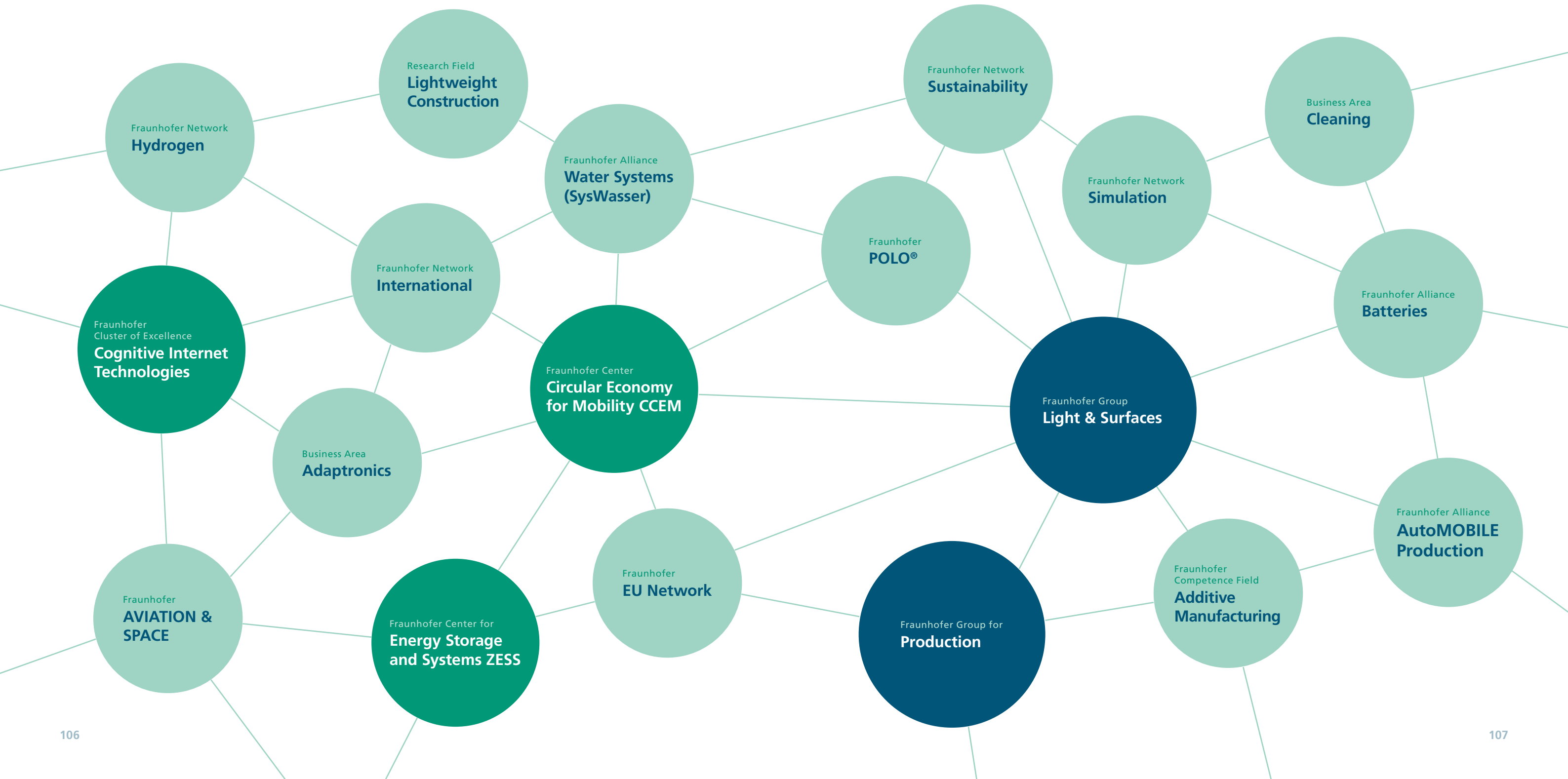
Networks within the Fraunhofer-Gesellschaft

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.

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 Circular Economy for Mobility CCEM in Wolfsburg.



Leading network of centers
for applied production research

Fraunhofer Group for Production

As part of the Fraunhofer-Gesellschaft, the largest organisation for applied research in Europe, the Fraunhofer Group for Production was founded in 1998. Today, 13 Fraunhofer institutes and centres pool their expertise and offer innovative and sustainable solutions in the fields of production engineering and logistics to German and international companies.

The Fraunhofer Production Network understands industrial value creation, from product development through manufacturing processes and logistics right through to recycling. This is underpinned by cutting-edge applied research in the fields of production, engineering and computer science. Working together with industry, small and medium-sized enterprises and policymakers, the Network develops solutions to boost productivity, resource efficiency and the resilience of supply chains. As a high-tech driving force, the Fraunhofer Group for Production brings together interdisciplinary expertise, state-of-the-art research infrastructures and practical knowledge transfer formats. Companies gain access to a broad spectrum of technologies, methods and test environments across the entire value chain. The aim is to ensure the future viability of production systems and to actively support transformation processes.

Competency portfolio

The combined expertise of the member institutes covers all areas of industrial value creation and is continuously being developed:

- **Production machinery and facilities**
Factory planning, machine tools, robotic systems and maintenance to optimise and safeguard production capacity
- **Production and process technologies**
Manufacturing technology, particularly in subtractive and additive manufacturing, with a focus on process engineering, precision engineering and surface engineering
- **Product development**
Integrated solutions for systems, software and virtual-based engineering, from the initial idea through to market launch
- **Production control, automation and measurement technology**
Smart sensor technology, networked systems, AI-supported assistance systems for adaptive production processes
- **Business and value-added management**
Strategies, business models, and innovation and technology management for the digital transformation of value chain processes

Change in the chairmanship of the
Fraunhofer Production Group

With effect from 1 July 2025, Prof. Dr.-Ing. Christoph Herrmann, Director of the Fraunhofer IST, has taken over as Chair of the Fraunhofer Production Group. Together with Prof. Dr.-Ing. Steffen Ihlenfeldt as Deputy Chair, he will shape the strategic development of the Group. With his proven expertise in resource efficiency, the circular economy and sustainable production systems, Prof. Herrmann is driving forward sustainable industrial value creation. The Group would like to thank Prof. Dr.-Ing. Welf-Guntram Drossel for his many years of service as Chair.

In addition, the experts offer advice on the selection of the right solutions and continuously empower people in dealing with new innovations in production and logistics. Companies benefit from a wide range of collaboration models – from individual commissions to large-scale international projects. Strategic partnerships such as Enterprise Labs or Joint Innovation Platforms sustainably strengthen our partners’ innovative strength. Our collaborations offer access to the latest technologies, interdisciplinary expertise and a strong network spanning business, academia and politics. This results in practical solutions for efficient, resource-efficient and future-proof processes.

Based on the specific challenges facing industry, we develop application-oriented solutions for key sectors with a significant impact on economic efficiency, environmental sustainability and resilience:

- **Logistics and supply chain management**
Smart material flow systems, modern ICT software architectures and holistic approaches to resilient, transparent supply chains

- Automotive (assembly/disassembly, battery production)
- Mechanical and plant engineering (modular systems)
- Manufacturing (processes ready for series production, quality)
- Aerospace (high-precision manufacturing)
- Logistics (inventory, route and network optimisation)
- Medical engineering (device and implant development)
- Energy industry (hydrogen, Power-to-X technology)
- Electrical industry (yield and test automation)
- Construction industry (prefabrication, product passports)

Cooperation and future topics

The Fraunhofer Group for Production offers a multitude of services ranging from technology consulting and collaborative research through to the solving of requirements and challenges via collaborative implementation projects. In addition to “quick wins” from potential analyses and innovation workshops, feasibility studies and bespoke system developments and integrations are among the frequently implemented formats for successful cooperation with industry. The Group thereby designs and optimizes technologies, processes and products through to the production of prototypes and small series.

We invite you to engage in dialogue with us and work together to develop forward-looking solutions.

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The Fraunhofer Group for Production in figures



Operating budget¹:
365 million Euro



Industrial revenue²:
25.9 %

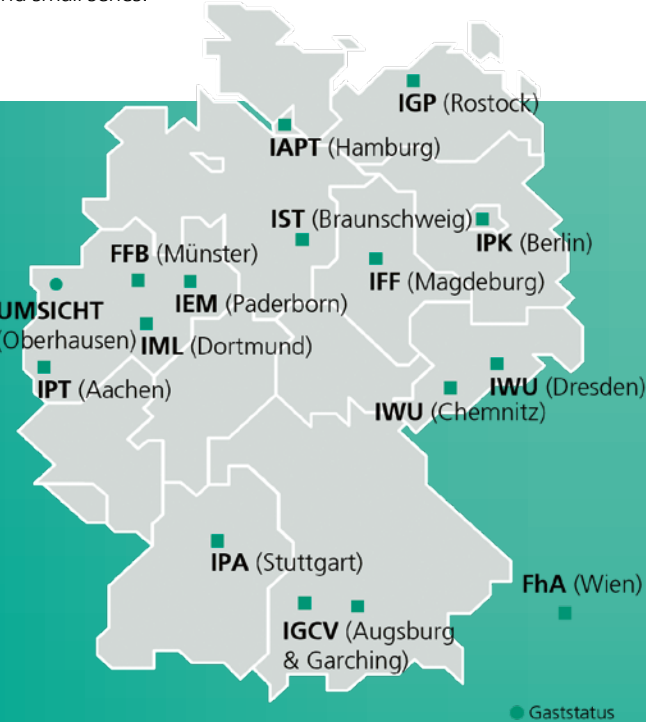


Employees³:
approx. 3,300

¹Budget 2024 / ²Result 2024 / ³2024 (sci./techn./adm. personnel)

Member institutes

The institutes of the
Fraunhofer Group for
Production represent the
leading network of
application-oriented
research in Germany.



Regional and nationwide networking

31 institutions – 70 locations – 19,600 employees: In order to network knowledge, sustainably promote innovation and strengthen the leading position of the Braunschweig science region, diverse scientific institutions in South-East Lower Saxony have joined forces to form the ForschungRegion Braunschweig e.V. Included among them are universities, colleges, federal research institutes, Helmholtz institutes, Fraunhofer institutes, Leibniz Association research establishments, museums, libraries and the Klinikum Braunschweig. Cooperation and partnerships already exist between many of these members and the Fraunhofer IST. The institute is also networked throughout Germany, beyond the ForschungRegion Braunschweig. The map shows examples of our network:



**The Competence Network
Industrial Plasma Surface Technology e. V.**

INPLAS

e.V.

We are

20

2005
2025

The Competence Network for Industrial Plasma Surface Technology e.V. aims to highlight the potential of plasma technology and to support, promote and facilitate developments across a wide range of application areas. The network is accredited under the 'go-cluster' programme of the Federal Ministry for Economic Affairs and Energy (BMWE) and has been awarded the Silver Label for Cluster Management Excellence. INPLAS celebrated its 20th anniversary in 2025 and currently brings together 52 members from industry and academia, with around 200 actively involved individuals. 75 percent of the members come from industry.

The following section presents highlights of INPLAS's diverse activities during the reporting year:

INPLAS working groups

The “Tool Coatings” working group, led by Hanno Paschke (Fraunhofer IST), and the “Digitalisation and AI” focus group, led by Marija Lindner (Institute for Machine Tools and Manufacturing Technology, IWF at TU Braunschweig), held a joint meeting in March 2025. The “Tool Coatings” working group addressed the machining of niobium carbide-based tools and current project proposals. The focus group centred on AI-based automation, the use of AI in complex planning scenarios, and data interfaces. Both groups were also given a tour of the IWF’s technical center.

The “Novel Plasma Sources and Processes (NPP)” working group, led by Dr Anke Hellmich (Applied Materials GmbH & Co. KG), Matthias Nestler (scia systems GmbH) and Dr Ulf Seyfert (Von Ardenne GmbH), focused at its 34th meeting at

Von Ardenne GmbH in May 2025 on topics such as catalytic CO₂ splitting and reduction, plasma diagnostics and plasma processes for heterogeneous integration at the 300 mm wafer level. The meeting in November 2025 at Bühler Alzenau GmbH focused on new developments in the field of plasma sources and included a tour of Bühler's production facilities.

The “Plasma4Production” working group was newly established during the reporting year, emerging from a strategic process at INPLAS. The aim of the working group is to address requirements across industrial production chains using low- and atmospheric-pressure plasma technologies, stable manufacturing processes, high quality standards and cost savings, within a climate of trust. Key topics include:

- Developing and consolidating a comprehensive understanding of processes on both the manufacturer's and the user's side
- Comprehensive and easily accessible process control
- Robust diagnostics and analytics suitable for production
- joint training projects



52 INPLAS members

INPLAS Member Overview (status 2025).



The “Plasma4Production” working group is led by Dr Stefan Wrehde (BSH Hausgeräte GmbH) together with Dr Kristina Lachmann (Fraunhofer IST) and Prof. Dr Peter Awakowicz (Ruhr University Bochum). At the meetings held at VON ARDENNE in May 2025 and at BSH Hausgeräte GmbH in September 2025, topics discussed included process monitoring of PECVD processes, barrier layers and applications of reactive ion etching. Insights into industrial manufacturing rounded off the meetings.

The Joint Committee on "Combined Surface Technology" met in Bremen and Braunschweig in 2025. The focus was on the current status of regulations governing per- and polyfluorinated chemicals (PFAS) and possible alternatives for the coatings industry, as well as the microstructuring of surfaces and thin films.

20th INPLAS General Meeting and Anniversary

The regular election of the INPLAS Executive Board took place during the 20th General Meeting at Bühler Alzenau GmbH. The following were elected: Dr Michael Liehr (W & L Coating Systems GmbH), Dr Moritz Oberberg (House of Plasma GmbH), Dr Ulf Seyfert (VON ARDENNE GmbH), Prof. Dr Michael Thomas (Fraunhofer IST), Prof. Dr Klaus-Dieter Weltmann (INP Greifswald), Dr Steffen Wetzel (Robert Bosch GmbH), Dr Stefan Wrehde (BSH Hausgeräte GmbH). This was followed by celebrations to mark the “20th anniversary of INPLAS e.V.”. The celebratory event provided an opportunity to look back on achievements to date and look ahead to future developments, whilst paying tribute to the commitment of numerous individuals. A particular highlight was the address by Ms Sabine Maass, Head of Unit for the “go-cluster” programme at the BMW. For many years, INPLAS has been actively promoting the visibility and continuous development of plasma technology through a variety of formats.

In an evening lecture, Prof. Holger Kersten (University of Kiel) highlighted the significance of plasma technology beyond technical applications – using the example of art conservation.

INPLAS Position Paper "Plasma and Surface Technology for the World of 2040+"

The latest position paper, “Plasma and Surface Technology for the World of 2040+”, was formally presented to Sabine Maass during the anniversary event by INPLAS Board Member Prof. Dr Michael Thomas and INPLAS Managing Director Carola Brand. The paper sets out the core values and objectives of plasma and surface technologies, particularly with regard to precision, efficiency, sustainability and digitalisation, and positions plasma technology as an enabler of innovation across a wide range of industries. The position paper was developed through the commitment of 13 experts from industry and academia, INPLAS board members, members, partners and the secretariat. It is being continuously developed and, using eleven application areas from the fields of life sciences, energy, mobility and manufacturing, highlights the future prospects of plasma technology and the resulting funding requirements.

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Memberships



Publications



Dissertations

Husmann, Jana Benita (2025). Handling multifunctionality in the life cycle assessment of electric vehicle batteries in a circular economy.

Justianto, Madeleine (2025). Heißdraht-CVD-Prozesse für Silizium-Heterostruktursolarzellen.

Reinders, Phillip Marvin (2025). Untersuchung und Modellierung der Oberflächeneigenschaften plasma-diffusionsbehandelter austenitischer Stähle.

Schott, Anna (2025). Vorgehensmodell zur Entwicklung und Herstellung von Dünnschichtsensoren für Produktionswerkzeuge

Patents granted

Vergöhl, M.; Pflug, A.; Bruns, S.; Zickenrott, T. (2025): Device and method for producing layers with improved uniformity in coating systems with horizontally rotating systems. US 12428720 B2

Vergöhl, M.; Pflug, A.; Bruns, S.; Kaiser, A.; Melzig, T.; Zickenrott, T. (2025): Device and method for coating substrates having planar or shaped surfaces by means of magnetron sputtering. US 12421592 B2

Vergöhl, M.; Pflug, A.; Bruns, S.; Kaiser, A.; Melzig, T.; Zickenrott, T. (2025): Device and method for coating substrates having planar or shaped surfaces by means of magnetron sputtering. CN 113646473 B

Vergöhl, M.; Pflug, A.; Zickenrott, T.; Bruns, S. (2025): Herstellung von Schichten ohne Uniformitätsmasken mit einer Plasmaquelle. US 12258661 B2

Schott, A.; Plogmeyer, M. (2025): Sensorisches Schichtsystem und Verwendung hiervon. DE 102022213858 B4

Vergöhl, M.; Rademacher, D.; Kricheldorf, H.-U.; Bräuer, G. (2025): Verfahren und Vorrichtung zur Herstellung partikelarmer Schichten auf Substraten. JP 7676466 B2

Vergöhl, M.; Rademacher, D.; Zickenrott, T. (2025): Verfahren und Vorrichtung zur Herstellung uniformer Schichten auf bewegten Substraten und derart hergestellten Schichten. US 12217947 B2

Vergöhl, M.; Melzig, T.; Bruns, S.; Farr, P. (2025): Verfahren und Vorrichtung zur Überwachung von Beschichtungsprozessen. DE 102023209929 B3

Flade, E.; Paulus, J.; Viöl, W.; Mainusch, N.; Siedenburg, T.; Torge, C. (2025): Vorrichtung und Verfahren zur reversiblen Kontaktierung. DE 102015212565 B4

Conference contributions

Bandorf, Ralf: Hollow Cathode Processes. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Bandorf, Ralf: Surface Engineering for Membranes & Barriers. International Conference and Exhibition for Vacuum | Plasma | Surface | Coating, 13.-16.10.2025 – Talk

Bandorf, Ralf: Future Control Demands and Challenges. Process Control in Production Lines - Latest Developments and Future Trends, 21.-22.1.2025 – Talk

Bandorf, Ralf; Gerdes, Holger: Application of Reactive Sputtering. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Bandorf, Ralf; Gerdes, Holger: Sputtering. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Barton, Dennis: Digital Modelling of an Industrial Inline Sputtering System - passing the Turing-Test for a practical application. 15th International Conference on Fundamentals and Industrial Applications of HIPIMS 2025, 25.-26.6.2025 – Talk

Barton, Dennis: KI – für die Prozess- und Anlagensteuerung. IFF Fachtagung »Datensicherheit und Datenmanagement«, 25.3.2025 – Talk

Barton, Dennis: Passing the Turing-Test for an Industrial Sputtering System. Plasma Process Simulation Tools for Industrial Coating and Etching Systems - Latest Developments and Future Trends, 11.-12.11.2025 – Talk

Barton, Dennis: Wozu Realität? – Die Grenzen der Digitalisierung in der Forschung. Salon der Wissenschaft, 18.6.2025 – Talk

Bruns, Stefan: Determination of Layer Thickness During Double-Side Coating. Optica OIC – Optical Interference Coatings Conference, 19.-23.5.2025 – Talk

Bruns, Stefan: Optical Characterization of Si-SiO₂ Quantizing Nanolaminates. Optica OIC – Optical Interference Coatings Conference, 19.-23.5.2025 – Talk

Bruns, Stefan: Simultaneous coating of double-side interference filters controlled by optical monitoring. International Conference and Exhibition for Vacuum | Plasma | Surface | Coating, 13.-16.10.2025 – Talk

Dietz, Andreas: Leben auf dem Mond. TransferTalk »Tag der Raumfahrt«, 28.3.2025 – Talk

Eberhardt, Klaus; Herrmann, Christoph: Nachhaltige Batterieproduktion – Herausforderungen und Chancen entlang des Battery Life Cycles. Batterieforum Deutschland 2025, 21.-23.1.2025 – Talk

Eberhardt, Klaus; Herrmann, Christoph: Nachhaltigkeit und Kohlendioxid-Fußabdruck. Batterieforum Deutschland 2025, 21.-23.1.2025 – Talk

Farr, Philipp: Development of a Compact Multi-Gradient Bandpass Filter for Hyperspectral Imaging in Smart Farming Applications. Optica OIC – Optical Interference Coatings Conference, 19.-23.5.2025 – Talk

Gerdes, Holger: Deposition Process Simulation. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Gerdes, Holger: Practice and Applications of High Power Impulse Magnetron Sputtering. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Gerdes, Holger: Reactive Sputtering – Active Monitoring and Control on Industrial Scale. RSD2025, 16.-17.3.2025 – Talk

Gerdes, Holger: Challenges in generating data for ML & KI. Process Control in Production Lines – Latest Developments and Future Trends, 21.-22.1.2025 – Talk

Grube, Michael; Philipp, Nina; Witt, Melina; Melzig, Sebastian; Zellmer, Sabrina: Scalable mechanochemical synthesis and thermal post treatment for an improved production process of Argyrodites. Batterieforum Deutschland 2025, 21.-23.1.2025 – Poster

Günther, Moritz: Measuring and Managing the CO₂ Footprint: Driving Innovation in Surface Technologies. International Conference and Exhibition for Vacuum | Plasma | Surface | Coating, 13.-16.10.2025 – Talk

Herrmann, Christoph: All engineers should be life cycle engineers with a mindset for absolute sustainability. 32nd CIRP Conference on Life Cycle Engineering (LCE2025), 7.-9.4.2025 – Talk

Herrmann, Christoph: Circular Economy in the thin film industry: Opportunities and challenges between regulation and rising customer expectations. International Conference and Exhibition for Vacuum | Plasma | Surface | Coating, 13.-16.10.2025 – Talk

Herrmann, Christoph: Nachhaltigkeitsbewertung und Life Cycle Engineering als systematische Innovationstreiber für die Schicht- und Oberflächentechnik. CO₂-Fußabdruck in der Dünnschichttechnik | Herausforderungen für Wirtschaft und Wissenschaft, 26.-27.5.2025 – Talk

Hora, Guido: Enhancing Long-Term Workforce Competence for the Green Hydrogen Economy: The Impact of asynchronous E-learning and Blended Learning Formats. Green Hydrogen Summit Oman (GH50) 2025, 30.11.-4.12.2025 – Talk

Körner, Stefan: VO₂:W coatings deposited by HIPIMS for thermochromic coatings in Architectural glass for energy saving applications. 15th International Conference on Fundamentals and Industrial Applications of HIPIMS 2025, 25.-26.6.2025 – Talk

Krinke, S.; Rohwer, V.: Implementing circular economy in automotive industry. 3rd European Automotive Decarbonization and Sustainability Summit 2025, Düsseldorf, 19.-20.3.2025 – Talk

Krinke, S.; Rohwer, V.; Lee, Z. J.: Decarbonization of the automotive value chain – Optimizing CO₂ reduction and costs. 3rd European Automotive Decarbonization and Sustainability Summit 2025, Düsseldorf, 19.-20.3.2025 – Talk

Krinke, Stephan: Decarbonization of the automotive value chain: Optimizing CO₂ reduction and costs. EMEA Automotive Carbon Neutral Summit 2025, 26.-27.11.2025 – Talk

Krinke, Stephan: Environmental, cost and technical performance of circular and low-CO₂ materials in car body engineering. WerkstoffPlus Auto, 19.-20.2.2025 – Talk

Krinke, Stephan: Implementing circular economy in automotive industry. European Automotive Circular Economy Summit 2025, 19.-20.3.2025 – Talk

Mann, Annika: Adhesion control by thin films deposited at atmospheric pressure processes. Iberian Industrial Workshop: Advancing to a Competitive Industrial Transition through Surface Engineering Solutions, 2.-3.10.2025 – Talk

Reus, Johanna: Characterizing adsorption and interaction of lipid nanoparticle systems to their primary packaging material. SPHERe 2025: 6th Braunschweig International Symposium on Pharmaceutical Engineering Research, 8.-10.10.2025 – Talk

Rohwer, V.; Lee, Z. J.; Krinke, S.: FutureCarProduction – A Life Cycle Engineering approach for sustainable car body development. LCM 2025, Palermo, Italien, 9.-12.9.2025 – Talk

Scheffler, Florian: Green hydrogen solutions for net-zero production and low-emission iron and steel pathways. Green Hydrogen Summit Oman (GHSO) 2025, 30.11.-4.12.2025 – Talk

Schulz, Philipp: Simulation of Particle Contamination Using the PALADIN Code. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Sittinger, Volker: Linear PVD Evaporator for C60/SnO₂ Layers in a SALD Hybrid System. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Stauß, M.; Rohwer, V.; Ali, A.; Herrmann, C.; Krinke, S.: Using absolute environmental sustainability for sustainable car body development. From Less Bad to Good Enough Conference, Dänemark, 30.09.-2.10.2025 – Talk

Stein, Christian: CVD-Diamond Coatings for High Performing Tools and Components. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Stein, Christian: Diamond Like Carbon Coatings – From Basics to Industrial Realization. 68th Annual SVC Technical Conference, 19.-22.5.2025 – Talk

Templin, Daniel: Development of Tribologically Optimized Tool Surfaces for the Cost-Efficient Forming of High-Strength Ti(Al) Alloys at 750–1250 °C. International Conference and Exhibition for Vacuum | Plasma | Surface | Coating, 13.-16.10.2025 – Talk

Ulrich, Stephan: Scale up of Vanadium dioxide-based thermochromic coating deposition for large area. pro flex 2025, 6.-7.5.2025 – Talk

Vergöhl, Michael: Magnetron Sputtering for High Performance Infrared Optical Coatings up to 14 µm. Optica OIC – Optical Interference Coatings Conference, 19.-23.5.2025 – Talk

Vergöhl, Michael: Wie High-Tech-Beschichtungen unsere Sicht ins All und auf die Erde verändern. TransferTalk »Tag der Raumfahrt«, 28.3.2025 – Talk

Weber-Hamann, Svenja: Enhancing Transparency: Reporting data reliability in prospective assessments of emerging battery technologies. 32nd CIRP Conference on Life Cycle Engineering (LCE2025), 7.-9.4.2025 – Talk

Weigel, Kai: Testing bio-based lubricants based on the soldier fly for sheet metal forming. INSECTA 2025, 14.-15.10.2025 – Talk

Zellmer, Sabrina: Chancen und Grenzen der Energie-speichertechnologie – Einblicke in die Batterie, Brennstoffzellen und Wasserstofftechnologien. H2-Innovation Camp 2025, 26.6.2025 – Talk

Zellmer, Sabrina: Fuel Cell Production Research. Hydrogen Technology Expo 2025, 22.10.2025 – Talk

Zellmer, Sabrina: Paths to energy self-sufficiency in manufacturing companies. REWIMET-Symposium Ressourcenmanagement 2025, 13.-14.8.2025 – Talk

Zellmer, Sabrina: System-Circular Economy: Destacking und R-Strategien. H2-Transfertage 2025, 24.-26.11.2025 – Talk

Zellmer, Sabrina; Lamp, Peter; Steinbacher, Nicolas F.; Hohenhoff, Rainer: Ökosystem Batterie - Technologie, Produktion und Regulatorik. Mobility Innovation Summit 2025, 25.-26.3.2025 – Talk

Picture index

Cover image	Fraunhofer IST, graphic: Nils Hildebrandt	47 (bottom)	Fraunhofer
2, 6/7, 8/9	Fraunhofer IST, photo: Daniel Böhme	48/49	Fraunhofer IST, photo: Falko Oldenburg
10, image 1	Fraunhofer IST, photo: Michael Thomas	50/51	Fraunhofer IST, graphic: Nils Hildebrandt
11, image 2, 3	Tantec A/S	52, 53	Fraunhofer IST, photos: Daniel Böhme
16	Fraunhofer IST, photo: Daniel Böhme	54	Fraunhofer IST, photo: Falko Oldenburg
17	Architektenbüro HDR	55	Fraunhofer IST, photo: Chris Britze
18	Fraunhofer IST	56	Fraunhofer IST, photo: Jan Benz
19	Fraunhofer IST, photo: Michael Thomas	57	Fraunhofer IST
22/23	Photo: Nils Hildebrandt	58, 59	Fraunhofer IST, photos: Daniel Böhme
24, image 1-6, 8-15	Fraunhofer IST, photo: Ulrike Balhorn	61	Fraunhofer IST, graphic: Nils Hildebrandt
24, image 7	Fraunhofer WKI, photo: Manuela Lingnau	61	adobe.stock.com, Viktor
25, image 16-26	Fraunhofer IST, photo: Ulrike Balhorn	62/63	adobe.stock.com, Mid
28, 30	Fraunhofer IST, photos: Daniel Böhme	64/65	Fraunhofer IST, graphic: Nils Hildebrandt
31	Fraunhofer IST	66, 68/69	Fraunhofer IST
32	Fraunhofer IST, photos: Frank Neumann	70	adobe.stock.com, Corona Borealis
33	Fraunhofer, photo: Markus Jürgens	71-73	Fraunhofer IST
34 (top)	adobe.stock.com, Frank Fichtmüller	74	adobe.stock.com, Teerasan
34 (bottom)	adobe.stock.com, Fahrul	76/77	adobe.stock.com, Ded Mityay
35, 36	Fraunhofer IST, photos: Daniel Böhme	78-86	Fraunhofer IST, photos: Daniel Böhme
36	Fraunhofer IST, graphic: Nils Hildebrandt	85	Fraunhofer IST
37	Fraunhofer IST	88	KWS, photo: Roman Thomas
38	Haus der Wissenschaft, Photo: Johannes Giering	89	aspheron, photo: Lars Kieschnik
39 (top)	Fraunhofer IST	90/91, image 1, 3	Fraunhofer IST, photos: Daniel Böhme
39 (bottom)	Fraunhofer IST, photo: Ulrike Balhorn	90/91, image 2, 4, 5	Fraunhofer IST
40	Fraunhofer IST	92	Fraunhofer IST, photo: Daniel Böhme
41	Wasserstoff Campus Salzgitter e.V.	94-97	Fraunhofer IST
42-45	Fraunhofer IST, photo: Daniel Böhme	98	Fraunhofer IST, photo: Ulrike Balhorn
42/43	Graphic: adobe.stock.de, Stafeeva	100/101, image 1, 2	Fraunhofer IST, photos: Daniel Böhme
46 (left)	Fraunhofer IST	101, image 3, 4	Fraunhofer IST
46 (center)	Unsplash, Nicholas Doherty	104/105	Fraunhofer, photo: Markus Jürgens
46 (right)	adobe.stock.com	105	adobe.stock.com, acrogame
47 (top)	Fraunhofer IST, photo: Ulrike Balhorn	112	Fraunhofer IST
		113	INPLAS

Imprint

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