Fraunhofer

News 1.25

Fraunhofer Competence Field
Additive Manufacturing

Formnext 2025

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Editorial

Welcome to Fraunhofer ADDITIV NEWS 1.25 – the formnext 2025 special issue of our Fraunhofer Competence Field Additive Manufacturing newsletter, introducing you to Fraunhofer's showcase at formnext 2025, presenting highlights from Fraunhofer's applied research in Additive Manufacturing (AM) and 3D Printing!
Our booth combines three major sections clustered by AM material type – metal, polymer, and multi-material (incl. ceramics) – complemented by a joint section of Fraunhofer ADDITIV and Fraunhofer PRODUCTION – adding not only biomaterials to the list of AM materials above, but also allowing our visitors to get the full picture of AM - from specific software solutions for AM up to AM-specific post-processing technologies.

Let me specifically highlight our biomaterial-related exhibits and the related articles in this NEWS edition – from Fraunhofer IAP's bio-based hydrogel resins to Fraunhofer IGB's fungal mycelium-based material – and our post-processing-specific showcases – Fraunhofer PRODUCTION's »turtle« that combines a wide variety of AM surface treatment solutions in one single demonstrator, Fraunhofer IWU's surface solutions to meet the food industry's high hygienic standards, and Fraunhofer ILT's SCaRB technology, that combines EHLA and roller burnishing.
When it comes to new fields and industry sectors for AM application, let me introduce you to Fraunhofer ILT's development of LPBF-made tungsten components for fusion reactors, Fraunhofer EMI's materials and designs for defence applications, Fraunhofer IGCV's repair solution for the maritime sector and Fraunhofer IGB's 3D printed meat! And, do not miss our cover story on Fraunhofer IMTE's solution for individualized clinical patientcare!
But there is much more to explore in this newsletter, with focus on AM process innovations, material developments, digital workflow improvements and functionalization of AM parts. We hope you enjoy reading and learning more about Fraunhofer's formnext 2025 exhibits!

Enjoy your formnext visit and start or continue your AM journey with Fraunhofer - meet us in hall 11.0, booth D31!

Dr. Bernhard Mueller
Spokesperson
Fraunhofer Competence Field Additive

Our Exhibitors

Fraunhofer Competence Field Additive Manufacturing

Office, Fraunhofer IWU, Dresden

The Fraunhofer Competence Field Additive Manufacturing integrates 20 Fraunhofer Institutes across Germany and represents the entire process chain of additive manufacturing. This includes the development, application and implementation of additive manufacturing methods and processes. Many years of experience from national and international industrial contracts and research projects form the basis to develop customer-specific concepts and master complex tasks.

Fraunhofer Institute for Material and Beam Technology IWS

Fraunhofer IWS, Dresden

Material and Laser with System: Fraunhofer IWS develops complex system solutions in laser and materials engineering. At Fraunhofer IWS, we see ourselves as drivers of ideas, developing solutions through laser applications, functionalized surfaces, and innovations in materials and processes – ranging from easily integrable individual solutions, to cost-efficient solutions for medium-sized enterprises, and up to fully industrial-grade turnkey solutions.

Fraunhofer Institure for Casting, Composite and Processing Technology IGCV

Fraunhofer IGCV, Augsburg

Fraunhofer IGCV stands for application-oriented research with focus on efficient engineering, networked production and smart multi-material solutions. Our unique selling proposition lies in interdisciplinary solutions for casting, composite and processing technology. A special highlight is our extensively equipped AMLab where we conduct application-oriented research on various processes, e.g. laser-based powder bed fusion of metals (PBF-LB/M), high pressure cold spray (CS), liquid metal printing (LMP) and binder jetting.

Fraunhofer Institute for Ceramic Technologies and Systems IKTS

Fraunhofer IKTS is your research partner for high-performance materials, especially ceramics, glasses and hard metals. The institute offers complete AM solutions ranging from powder and suspension/feedstock development, the design and development of (functionally graded) components, the manufacturing technology selection as well as thermal processing of AM components. As a plus, IKTS offers the characterization and assessment of the manufactured components and systems in each step of the entire process chain.

Fraunhofer IKTS, Dresden

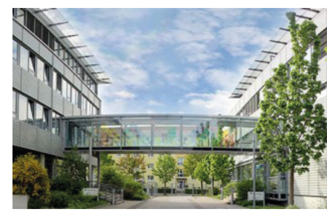
Fraunhofer Institute for Machine Tools and Forming Technology IWU

Fraunhofer IWU is a driver for innovations in the research and development of production engineering. Around 670 highly qualified employees at our locations in Chemnitz, Dresden, Leipzig, Wolfsburg, and Zittau tap the new potential for competitive manufacturing in mechanical, automotive, aerospace, medical, electrical and precision engineering - from the specific component to the entire factory. Today, Additive Manufacturing is one of IWU's major distinct research topics, encompassing metal and polymer-based AM technologies.

Fraunhofer IWU, Chemnitz, Dresden, Zittau

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

Fraunhofer IFAM offers the whole range of metal powder-based AM processes to provide thorough access to the various possibilities of additive manufacturing technologies. The comprehensively equip ped additive manufacturing application center at Fraunhofer IFAM in Bremen comprises the complete process chain for PBF-LB and MBJ². At Fraunhofer IFAM in Dresden, the Innovation Center Additive Manufacturing ICAM® brings together PBF-EB, 3D Screen Printing, FFF4, Gel Casting, MoldJet® and LMM5 under one roof.



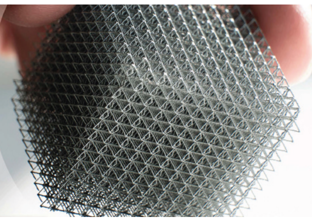
Fraunhofer IFAM, Dresden and Bremen

Fraunhofer Institute for Laser Technology ILT

Fraunhofer ILT, Aachen

With more than 550 employees and more than 40 spin-offs, the Fraunhofer Institute for Laser Technology ILT in Aachen is one of the leading contract research and development institutes in its field. For more than 35 years, the Fraunhofer ILT experts have been developing and optimizing laser beam sources and laser processes for production and metrology, energy and mobility, medical and environmental technology, as well as quantum technology.

Fraunhofer Cluster of Excellence Programmable Materials CPM



Fraunhofer CPM

The Fraunhofer Cluster of Excellence Programmable Materials (CPM) consists of the six core institutes Fraunhofer IWM, IAP, IWU, IBP, ITWM, and ICT. In total, 17 Fraunhofer institutes are involved in the cluster. Programmable materials are materials or material composites whose structure is designed in such a way that their properties can be deliberately controlled and reversibly changed. Programmable materials offer a unique potential for new system solutions, as they take over essential system functionalities themselves, making additional system components such as sensors or actuators unnecessary. Fraunhofer CPM has started establishing Additive Manufacturing as a key enabler for Programmable Materials.

Fraunhofer Group for Production

Office, Fraunhofer IFF, Magdeburg

The Fraunhofer Group for Production unites 13 institutes and research units offering innovative system solutions in the wide field of production technology and logistics. The range of services covers the entire value creation process. In the field of additive manufacturing, our institutes can provide solutions in upstream and downstream processes of the value creation chain. The consolidated expertise covers digitalization and networking of tools and AM machines, hybrid manufacturing chains, product engineering, quality assurance and rework, training and AM material flow.At Formnext 2025, the special focus will be on showcasing technology solutions and process innovations in the field of post-processing and its automation - from surface finishing and functional coating to automated support removal, internal channel processing, and sustainable repair approaches.

DDMC 2025 | Berlin | March 12-13, 2025

DDMC2025 Fraunhofer Direct Digital Manufacturing Conference

Recap your DDMC 2025 experience, or check out what you have missed!

5 exciting Keynote Presentations:

https://www.ddmc-fraunhofer.de/en/keynotespeaker.html

Top 9 Papers in Springer PIAM's Collection „Direct Digital Manufacturing":

https://link.springer.com/collections/aijdadciif

Full Conference Proceedings: https://dx.doi.org/10.24406/publica-4413

More than 110 participants from 13 countries and 3 continents attended the 7th Fraunhofer DDMC on March 12th and 13th 2025, in Berlin, Germany. The conference program included 5 inspiring keynotes from Prof. Enrico Stoll, Prof. Wojciech Matusik, Ben Hartkopp, Prof. Bianca Colosimo, and Dr. Sebastian Piegert & Dr. Cynthia Wirth and 67 oral presentations clustered in 22 sessions.

At the end of the conference the Best Poster (Aron Pfaff of Fraunhofer EMI, Germany), Best Presentation (Ligeia Paletti of DLR, Germany) and Best Paper (Eike Tim Koopmann of Mercedes-Benz, Germany) have been awarded in a specific ceremony.

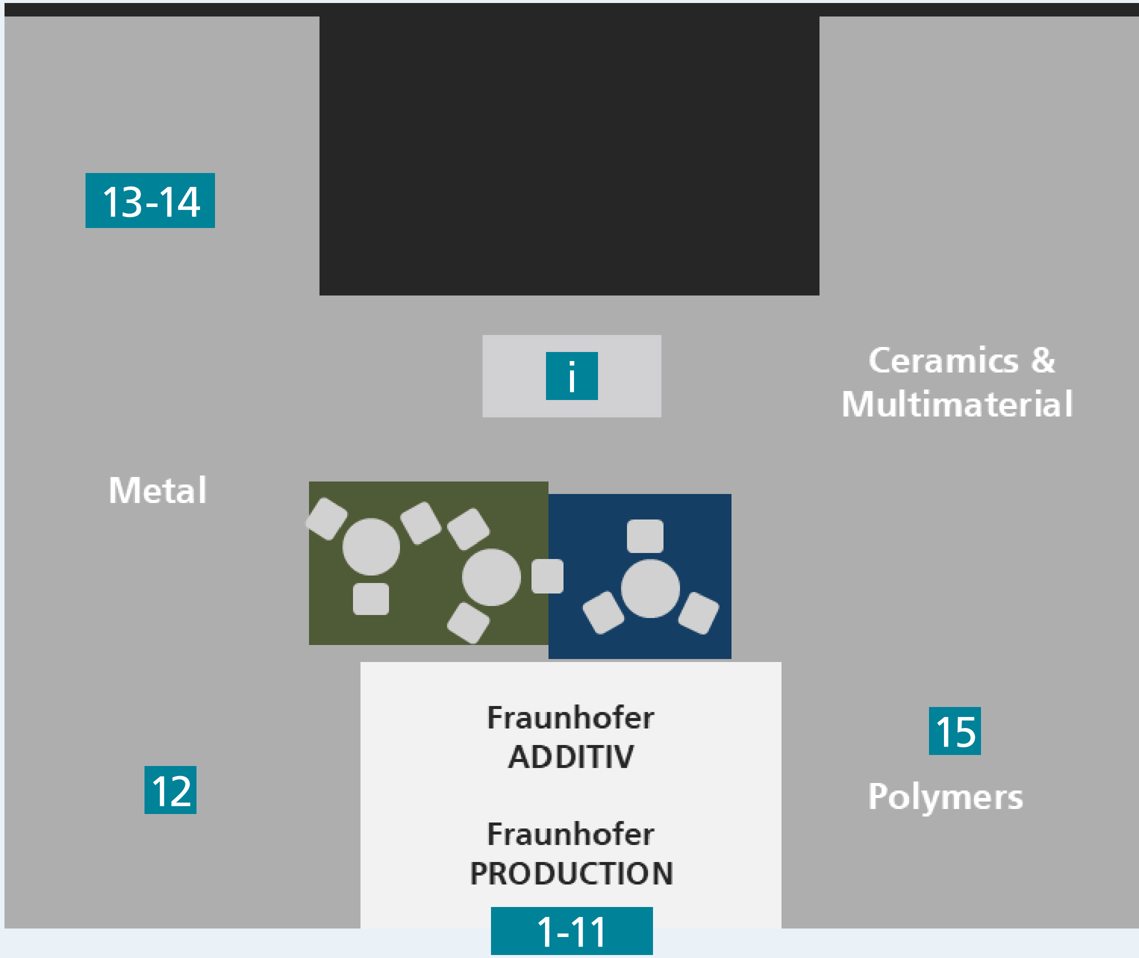
DDMC would like to thank its Exhibitors and sponsors SEMPER-KI and ALD Vacuum Technologies GmbH for enriching and supporting the conference, as well as DDMC's industrial media partners x-Technik IT & Medien GmbH and Inovar Communications.

DDMC holds special appreciation to its Scientific Committee for supporting the conference, by reviewing so many submitted papers and helping us to maintain the high scientific and technological standard of Fraunhofer DDMC!

We are looking forward to meeting you at the next Fraunhofer DDMC in 2027
- stay tuned for more details!

DDMC2027 Fraunhofer Direct Digital Manufacturing Conference

Content



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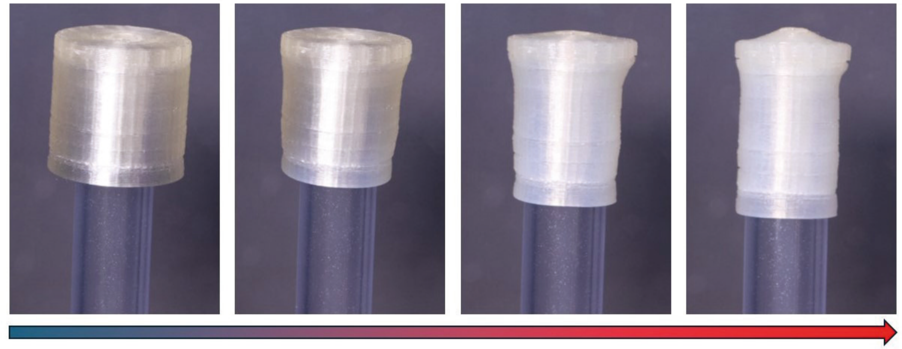

Thermoresponsive connecting elements, sealing caps and morphing structures

Four-dimensional (4D) printing enables the production of objects with thermorespon-sive properties.

At the Fraunhofer IAP, novel shape memory polymers are synthesized on a customer-specific basis and additive manu-facturing tests are carried out using the fused filament fabrication process.

The printed objects are then tested and evaluated with regard to their functiona-lity. Such approaches enable 4D printing directly on site, which makes them attracti-ve in the infrastructure sector, for example - whether sealing transport lines, closing pipes or connecting hose systems.

An additional advantage: the materials used also offer corrosion protection. Anot-her field of activity is shape morphing, in which printed objects initially have a planar shape, for example, before the release of internal stresses leads to the corresponding structures being raised. Self-unfolding objects save space during transportation and are attractive for applications in the aerospace, toy and furniture sectors.

Fraunhofer Institute for Applied Polymer Research IAP

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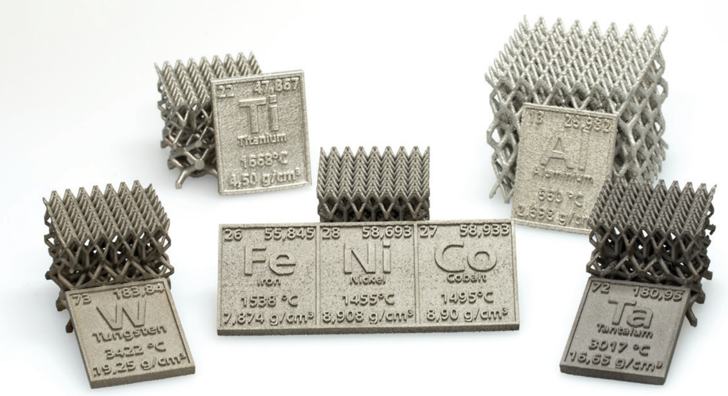

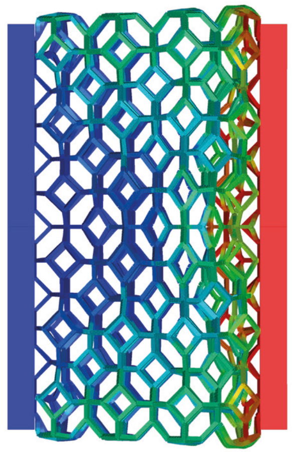

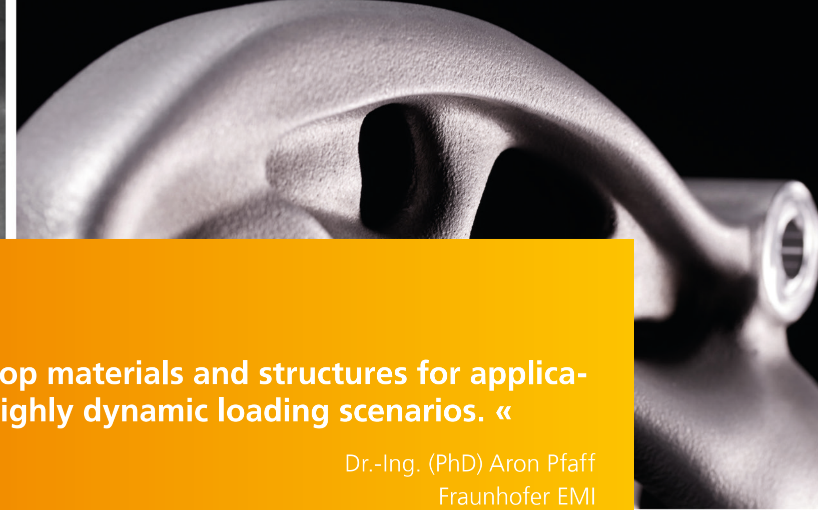

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Additive Materials and Design for Dynamic Loading Applications

Enhancing Performance in Safety, Security, and Defense

We develop materials and structures for applications in highly dynamic loading scenarios through additive design and manufacturing, enabling novel solutions such as enhanced crashworthiness, blast mitigation, or ballistic protection. This comprises the development of materials with tailored properties as well as the optimization of structural design. Our capabilities cover design, simulation, material development, and testing.

Optimization of Kinetic Energy Absorbers

We develop dedicated optimization methods to enhance the performance of cellular structures under dynamic loads. Our methods can be applied for a wide range of impulse transmission scenarios, including helmets, body armor, protective gear, battery safety, transportation or blast mitigation.

- Optimization of cellular structures on micro-, meso-, and macro-scale
- Developing AI-supported optimization approaches
- Auxetic lattice and minimal surface structures
- Simulation of blast and impact loads
- Experimental validation for crash, impact, and blast

»

We develop materials and structures for applications in highly dynamic loading scenarios. «

Dr.-Ing. (PhD) Aron Pfaff
Fraunhofer EMI

Metallic Materials for High-Speed Dynamics

We offer steels and heavy metals engineered for dynamic loads and target material-specific challenges such as micro-cracks. Our expertise in process parameter development enables the creation of functionally graded microstructures to enhance or tailor the mechanical properties for specific applications.

- High-performance steels: armor, high-strength, tough
- Processing of heavy metals: tungsten, tantalum, copper
- Metal-matrix composites: W-Fe, W-Ta
- Microstructural gradients
- Adapting mechanical properties

Multidisciplinary Design Optimization

To reduce weight and integrate functionality, we develop generative, simulation-driven design workflows for structures under multiphysics loads. Multidisciplinary topology optimization, allow the design of light-weight structures while meeting performance constraints. A key focus lies on layouts for crash-, blast-, and impact-loaded components.

- Multiphysics optimization
- AI-supported generative design
- Structural design for crash, blast, and impact
- Implementing plug-in tools and workflows in commercial software

Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institute EMI

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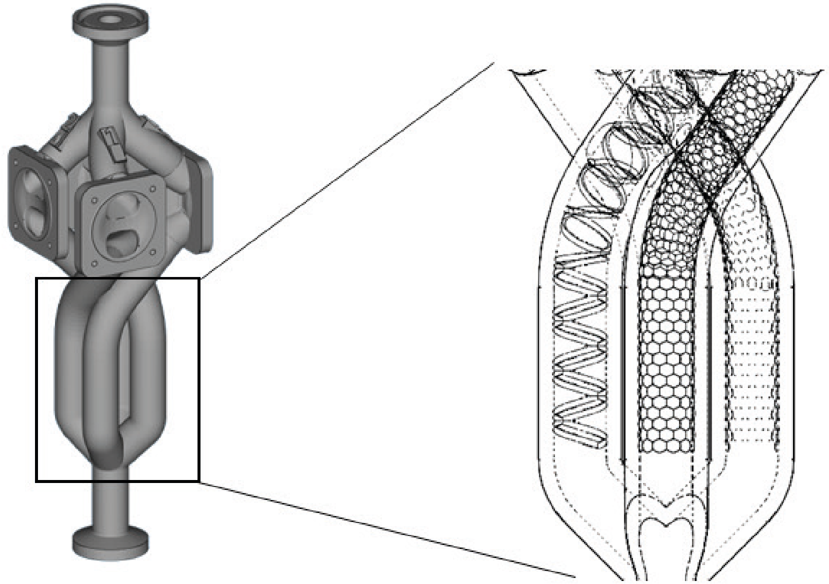

Figure 1: HygAM 2 Demonstrator © Fraunhofer IWU

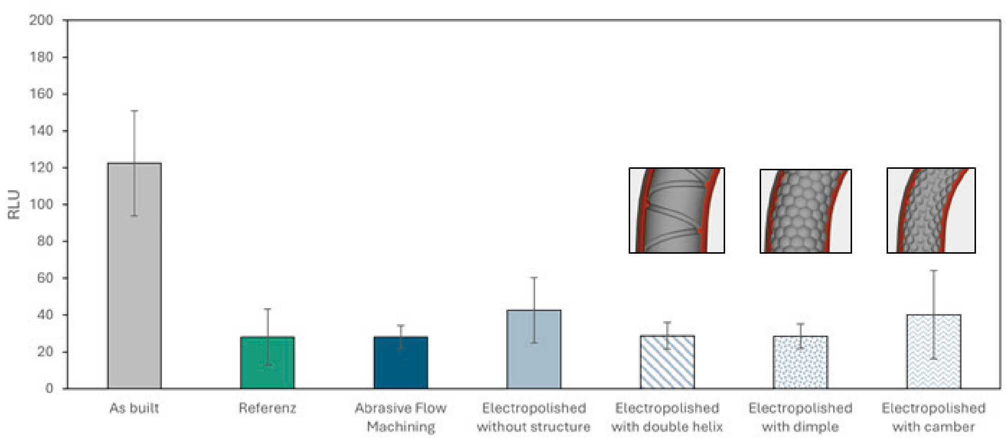

Figure 2: Cleanliness of various surfaces with differing surface properties following a standardized cleaning procedure. © Fraunhofer IWU

Laser Powder Bed Fusion in the Food Industry

Strategies for Surface Modification to Eliminate Residual Contaminants

Metallic 3D printing holds great potential, but its application in industries such as food and pharmaceuticals is limited by insufficient surface roughness. Within the HygAM and HygAM 2 projects, the effects of post-processing methods and macro-structures on the surface properties and the cleanability of 3D-printed components for hygienic purposes were investigated. Various structuring approaches were analyzed and their impact on cleanability demonstrated. It was shown that both macro-structuring and post-processing can achieve macroscopic and microbial cleanability. Combining post-processing with macro-structuring further improves microbial cleanability to a level comparable with conventionally manufactured pipes.

In Figure 2, the Relative Light Units (RLU) are shown; this is a unit of measurement in bioluminescence cleanliness measurement used to quantify the amount of adenosine triphosphate (ATP), adenosine diphosphate (ADP) and adenosine monophosphate (AMP) on a surface. The RLU value indicates how clean a surface is: the lower the value, the less contaminant is present and the cleaner the surface.

As a project outcome in HygAM 2, a valve block specifically designed for 3D printing was developed. The block's channels feature various simulation-designed patterns which, in combination with post-processing, meet the reference contamination values (cp. Figure 1).

Fraunhofer Institute for Machine Tools and Forming Technology IWU

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3D-printed star made from mycelium-based ink — a symbol of susainable innovation in additive manufacturing. © Fraunhofer IGB

Sustainable Innovation in 3D Printing: Bio-Based Materials from Fungi

Engineered Living Materials for AM

Fungal mycelium is emerging as a promising base material for a new generation of sustainable, bio-based composites. These materials are biodegradable and made from renewable resources — they are also versatile in application, suitable for use in packaging, acoustic panels, construction elements, insulation, and functional components. Within the EU-funded project LoopOfFun, Fraunhofer IGB researches "Engineered Living Materials" (ELMs): biologically active structures based on living fungal cells that grow into predefined shapes and may adapt or self-heal in response to environmental stimuli. Some ELMs are kept alive — for instance, in bioactive filters — while others are deactivated after shaping, e.g., by heating, for durable building components.

Award-winning research on mycelium inks

In his bachelor's thesis, in close collaboration with Fraunhofer IGB, Niklas Hug focused on reproducible mechanical evaluation of 3D-printed mycelium materials. The bioink consists of living fungal cells, agricultural by-products, and natural binders that ensure the paste flows smoothly during printing and maintains its shape. As the fungus grows, its mycelial network strengthens and binds the structure. Hug fabricated mechanical test specimens using additive manufacturing and compared them with molded samples. His results — based on tensile, compression, and nanoindentation tests — form a protocol for future qualification and optimization of sustainable, mycelium-based feedstocks. Recognized for Sustainability and Innovation, Niklas Hug was honored with the Sustainability Award of the degree program Material Design – Bionics and Photonics for bridging biology, materials science, and digital fabrication.

> **» Mycelium-based, biologically active materials are revolutionizing AM by providing sustainable, versatile, and self-healing solutions. «**
>
> Dr. Achim Weber
> Fraunhofer IGB

Towards biointelligent additive manufacturing

Fraunhofer IGB sees great potential in mycelium-based ELMs — particularly for sustainable lightweight structures, biodegradable components, and biologically active filters. While similar results can be achieved by growing mycelium in molds, 3D printing enables freeform, precise design and faster prototyping. Combining sustainability, biological functionality, and digital manufacturing, these living materials open new pathways for future biointelligent systems.

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

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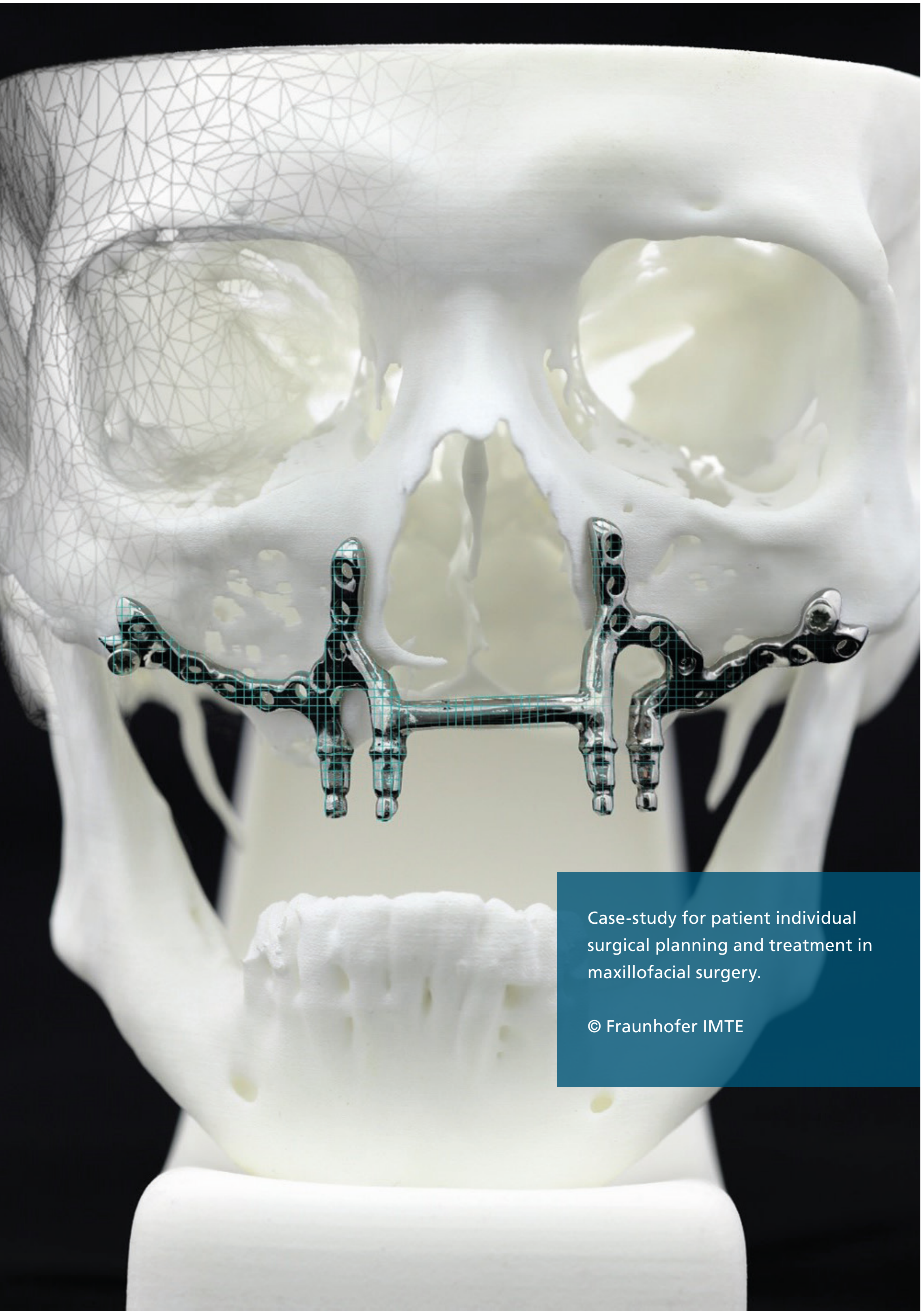

Case-study for patient individual surgical planning and treatment in maxillofacial surgery.

Individualization of clinical patientcare

Train, diagnose, plan, produce, treat, recover

Patient care is being improved through the individualization of clinical workflows and associated tools. Considering post-therapeutic rehabilitation, new solutions are being developed to streamline the patient journey – from data-based diagnosis using imaging and scans to treatment planning and recovery. Additive manufacturing has demonstrated significant potential in tailoring treatments, including the design and production of surgical guides and implants, leading to sustainable and patient-friendly outcomes.

From a patient-centered perspective, sustainability also includes the prevention of follow-up treatments. This preventive strength is a key aspect of individualized healthcare and contributes to clinical efficiency.

An environment has been created that enables the transfer of cutting-edge research into clinical practice. Clinical settings are simulated within dedicated laboratories, including fully equipped operating room environments located adjacent to manufacturing platforms for polymers and metals. Certified nondestructive dimensional testing in accordance with ISO 17025, using computed tomography, is available to monitor and verify the specifications of manufactured components throughout the entire development process.

In this way, additive manufacturing is supported in demonstrating its full potential in medical engineering and in expanding its clinical relevance.

Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE

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From Additively Manufactured Semi-Finished Part to Industrial Component

The Final Layer Makes the Difference

Additive manufacturing offers design freedom, functional integration, lightweight structures, and resource-efficient production. But the decisive step from printed part to industrial component happens in post-processing. Under the title "Additive Manufacturing – Finishing and Refinement Solutions", the Fraunhofer Group for Production presents a broad spectrum of advanced technologies that unlock functional performance and industrial viability. The wide range of technologies on show includes:

- Machining processes such as milling, sandblasting, or vibratory grinding for smooth, assembly-ready surfaces, even in multi-material parts.
- Plasma treatments, which clean and polish while improving adhesion and wettability, for instance, in hybrid polymer-metal bonding.
- Laser structuring, which creates functional micro-patterns for controlled friction, liquid transport, or anti-reflection.
- Selective coating and painting, which add targeted properties like conductivity, chemical resistance, or optical effects.

» Additive processes typically produce semi-finished parts that become high-quality end products through post-processing. «

Stefan Gräfe M.Eng.
Fraunhofer IPT

These post-processing techniques transform additively manufactured parts into robust, application-specific components. Post-processing also contributes to circular manufacturing: repairing worn plastic parts and incorporating recycled materials helps extend product life and reduce resource consumption - combining sustainability with high performance.

To scale up additive manufacturing for industrial use, automation is essential. The Fraunhofer Group will showcase robotic systems for automated support removal - enabling consistent, time-efficient workflows. Internal features such as cooling channels pose additional challenges. Here, abrasive flow machining and electrochemical removal provide precise inner surface finishing - even in hard-to-access, complex geometries.

These diverse technologies converge in a tactile turtle exhibit. Each segment of the turtle was treated with a different refinement process, offering a hands-on demonstration of how the final layer adds measurable value - turning a printed shell into a functional, industrial-grade part.

Fraunhofer Group for Production

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»In the near future Cold Spray will make a significant contribution to corrosion prevention.«

Philipp Kindermann, M. Eng.
Fraunhofer IGCV

Enabling Cold Spray for the maintenance of maritime port infrastructure

A brief summary of this novel approach

Cold Spray is a metal-coating process, which was developed in the 1980s. In recent years, it has attracted particular attention as an additive manufacturing process and also as an innovative repair technique. The latter aspect presents an opportunity to recondition maritime steel structures in German ports and worldwide. These parts represent a considerable investment value but are continuously damaged by corrosion.

German seaports are struggling with the issue of aging sheet pile walls, which typically have a lifespan of only 10 to 30 years. This deterioration raises significant concerns regarding critical infrastructure. One of the main culprits is corrosion, which severely weakens these structures, resulting in thinner walls and thus to the formation of holes. Several factors contribute to the acceleration of corrosion, such as wave action and saltwater exposure, particularly affecting the used basic construction steels like S235JR. This challenge is addressed in a research project called "NIMBUS" with a consortium of port operators, research institutes, and corrosion protection specialists. In addition to collecting data to precisely determine the corrosion rates, innovative repair processes are examined in more detail, with a focus on Cold Spray. Initial test results show that the corroded sheet pile walls can be coated using this process. So far, the spraying of almost identical structural steel for re-thickening and the spraying of sacrificial anodes made of pure zinc have been considered. The preparation of the sheet pile wall is of central importance: Rust must be completely removed beforehand to achieve the most homogeneous and closed surface layer possible. Further materials must be qualified to reduce costs and achieve higher deposition rates. Furthermore, a concept must be developed to be able to renovate the sheet piling in the harbor using Cold Spray.

With these efforts, it should be possible to significantly improve the longevity and safety of port infrastructure. Thus, Cold Spray presents a promising potential for the sustainable maintenance and enhancement of the lifespan of port infrastructure.

Fraunhofer Institute for Casting, Composite and Processing Technology IGCV

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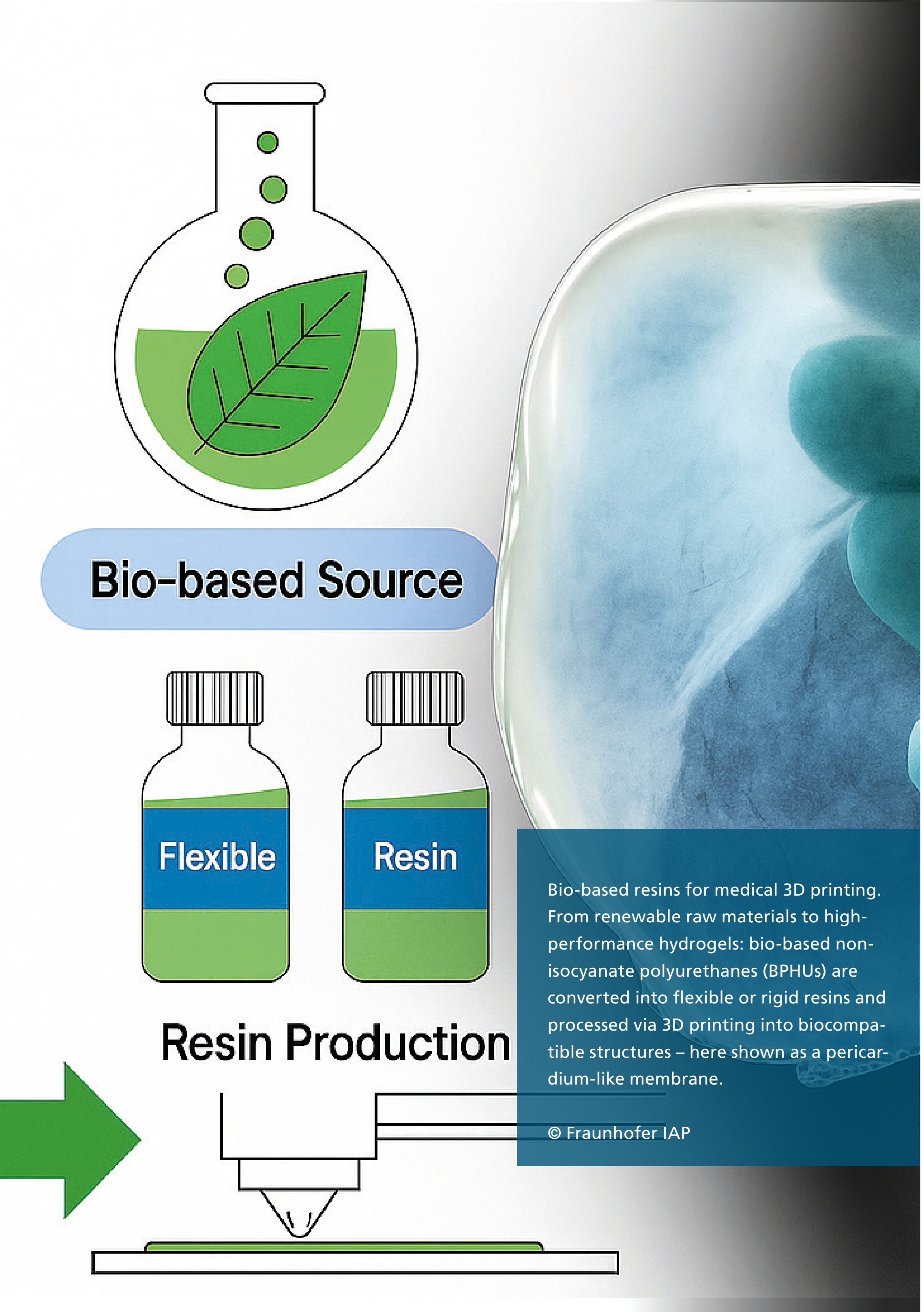

Bio-based resins for medical 3D printing. From renewable raw materials to high-performance hydrogels: bio-based non-isocyanate polyurethanes (BPHUs) are converted into flexible or rigid resins and processed via 3D printing into biocompatible structures – here shown as a pericardium-like membrane.

Bio-based Resins for Next-Generation Biocompatible Hydrogels

Advancing the development of customized materials for medical applications is a central goal of polymer research. One milestone achievement has been the creation of an artificial pericardium that biomimetically reproduces the mechanical and biological properties of the natural heart sac. Produced via 3D printing, this material is elastic, biocompatible, and durable – making it a highly promising candidate for use in cardiac surgery, particularly in implant development.

Building on this success, researchers have now taken a decisive step forward: the development of a new class of 3D printing materials that combine sustainability with exceptional biocompatibility. As recently reported by Hennig et al. (2025), conventional printing resins have been successfully synthesized from renewable, bio-based raw materials.

The breakthrough lies in the use of bio-based, non-isocyanate poly(hydroxyurethanes) (BPHUs). Derived from renewable resources, these polymers eliminate the need for toxic precursors. Through targeted chemical modification, they become photoreactive and can be cured with UV light – just like conventional resins.

The result is a new family of printable hydrogels with customizable properties:

- Aliphatic route: Produces hydrogels that are especially flexible and adaptable, ideal for applications requiring high elasticity.
- Aromatic route: Yields stiffer, mechanically robust hydrogels well-suited for load-bearing structures and implant applications.

Extensive cytotoxicity testing in accordance with DIN EN ISO 10993-5 has confirmed the excellent biocompatibility of both material variants. This work opens the door to a new generation of sustainable, high-performance materials for medical 3D printing – from patient-specific implants to innovative tissue engineering solutions.

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© Fraunhofer IPA

Qualification of PC for Laser-Based Powder 3D Printing

Fraunhofer IPA developed a sustainable PBF printing process using polycarbonate (PC)

The project examined how polycarbonate (PC) behaves during the PBF-LB/P process. Innovative strategies were developed to process the amorphous plastic at low bed temperatures.

The PBF-powder producer Lean Plastics Technologies GmbH has initiated a feasibility study aimed at developing a novel powder for the highly relevant industrial 3D printing process PBF-LB/P. At present, the market is dominated by polyamide 12 or 11, which are used in around 90% of applications. However, to broaden the range of possible applications for this technology, new and innovative powder materials are required. In the study, PC – an amorphous thermoplastic – was tested for its suitability in PBF-LB/P processing. The material must meet multiple requirements: a precise particle size distribution and excellent flowability to ensure uniform layer application in the printer. During processing, the laser must be capable of fusing the material into dense layers with high precision.

As part of a ZIM-funded feasibility project, Lean Plastics Technologies' proprietary powder production technology was applied to PC and subsequently tested by Fraunhofer IPA for its processability in the PBF-LB/P method. The Fraunhofer team set itself the ambitious goal of developing a process with maximum sustainability. Unlike conventional approaches, where the ambient temperature is kept close to the material's softening point, the aim here was to work at significantly lower temperatures. This would reduce polymer aging and allow for complete reuse of unmelted powder.

»The project results have impressively demonstrated to us that PC has great potential for powder-based 3D printing.«

Matthias Düngen, CEO
LEAN PLASTICS TECHNOLOGIES GmbH

Following the successful production of a free-flowing PC powder, initial processing trials were conducted at Fraunhofer IPA using a small industrial PBF-machine. Process parameters were first determined experimentally using simple test geometries. The trials quickly revealed the powder's high potential for additive manufacturing. By optimizing laser power, scan speed, and hatch distance, the researchers produced the first demonstration parts at moderate installation temperatures.

After only three months of intensive research, Fraunhofer IPA scientists demonstrated the powder's excellent processability in a series of test geometries. Notably, the unused powder showed no signs of aging and could be completely reused without any loss in quality. This breakthrough marks a significant step toward more sustainable and versatile material solutions for the PBF-LB/P process.

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

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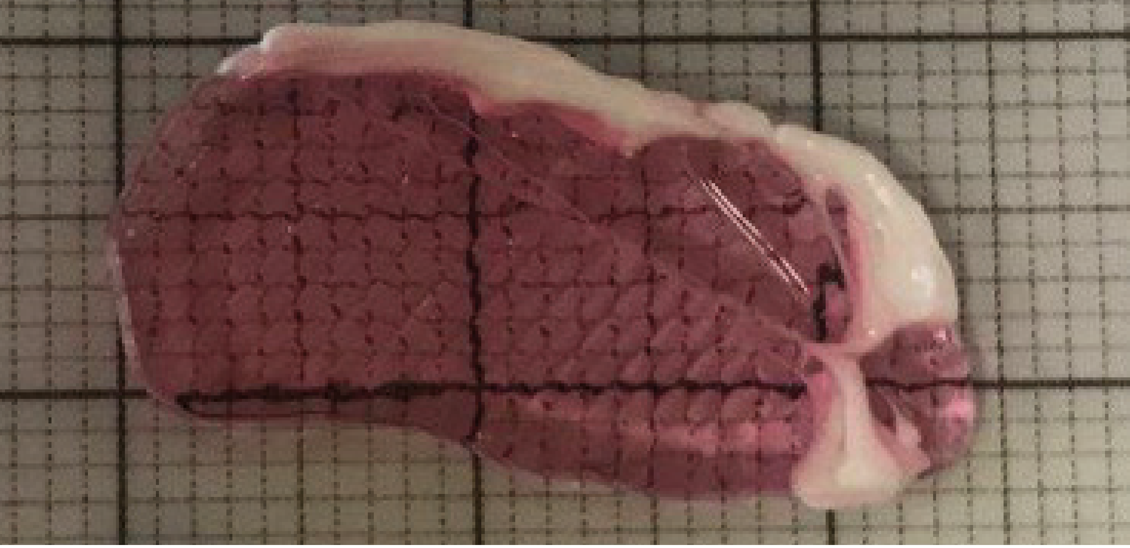

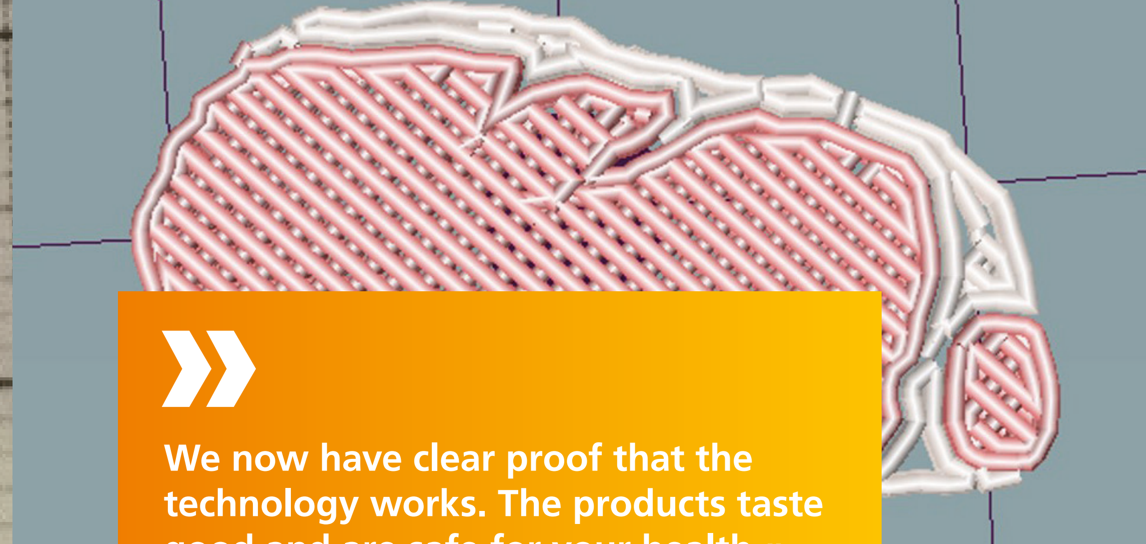

3D bioprinted meat-like structure and 3D-CAD model © Fraunhofer IGB

Novel Food – from bovine cells to bioengineered fat for cultivated meat

Lab-grown meat – eating without killing animals

Cultivated meat holds the potential to revolutionize the meat industry by cutting down on both animal suffering and resource consumption. Since cultured fat plays a key role in replicating the flavor and texture of beef, new strategies are needed for growing and differentiating primary bovine cells in dynamic, antibiotic-free environments.

What is cultivated meat and how is it produced?

Cultivated meat represents an innovative biotechnological approach to producing meat without slaughtering animals. Instead of raising livestock, small tissue biopsies are taken from living animals, and the extracted cells are multiplied in controlled bioreactors. These cells grow in nutrient-rich, carefully tailored media, eventually forming a cell mass that can be combined with edible carrier materials to create final products. Depending on the process, this mass may consist of individual cells or three-dimensional aggregates such as spheroids. In some cases, additional carriers known as "microcarriers" are used to support cell growth. Beyond simple cell multiplication, a crucial step is guiding the cells to mature into muscle or fat, which are essential for replicating the taste and texture of conventional meat. Biofabrication technologies enable further processing of the cultured cells. Methods include encapsulating them in edible substances like hydrogels and employing 3D bioprinting to shape structured, meat-like products.

»We now have clear proof that the technology works. The products taste good and are safe for your health.«

Prof. Dr. Petra Kluger

What we did so far

We have developed cultured fat in the form of spheroids, designed to serve as building blocks for future cultivated meat products. The focus was on methods that avoid antibiotics and use only animal-free, edible carrier materials, making the approach suitable for commercial use. We created streamlined protocols for guiding cells to differentiate, forming spheroids, and 3D bioprinting them within carrier materials — steps that could make large-scale production easier. Testing revealed that the fatty acid profile of the lab-grown fat closely mirrors that of native bovine fat, bringing it one step closer to matching the taste and texture of traditional meat.

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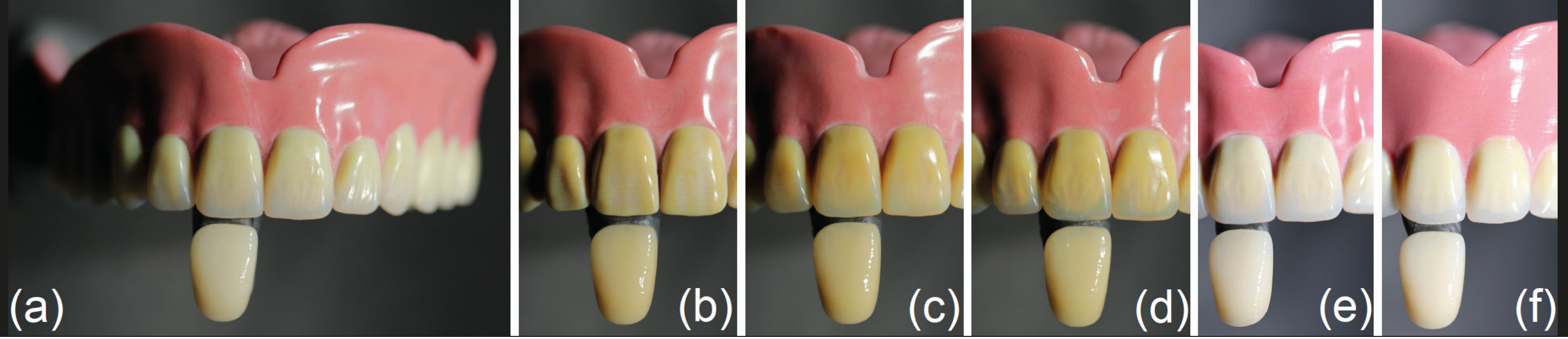

Biomimetic Multi-Material 3D Printing for Shade-Accurate, Lifelike Dentures

3D printed dentures illustrating the versatility of the approach with teeth consisting of enamel, dentin and root layers printed to match the A2 shade (a), the B4 shade with increasing enamel translucency from almost opaque (b), translucent (c), to highly translucent (d), and the A2 shade with different inner layer structures (e) and (f) but similar outer shape (pictures were taken with larger exposure than (a)). The teeth below are conventionally manufactured shade references. © Fraunhofer IGD

Additive manufacturing has rapidly advanced within dental technology, yet the faithful reproduction of natural teeth remains a challenge due to the complex interaction between materials and light within the tooth's internal anatomy. A tooth's natural appearance is governed by the multilayered structure of enamel, dentin, and root, whose distinct optical properties together define both the perceived color and the lifelike look of teeth.

Recently, the first material jetting printers with FDA- and MDR-certified resins have entered the market, enabling for the first time the regulatory-compliant production of multi-material monolithic dentures. However, current commercial solutions do not replicate the internal anatomical tooth structure, which limits the achievable aesthetics of printed teeth.

A new research project presented at SIGGRAPH[1] introduces a novel biomimetic workflow that directly addresses this gap by combining multi-material jetting with AI-based color prediction models. By embedding enamel, dentin, and root layers into the digital tooth model, and by predicting material mixtures for shade accuracy, the method reproduces not only the external shape and color but also the internal optical behavior of natural teeth. This approach allows dental technicians to adjust the translucency of dentin and enamel layers to optimize aesthetics without altering the overall shade of the teeth.

Extensive evaluation against industrial references demonstrated that the system can reproduce shades with high accuracy. Median CIEDE2000 errors at primary evaluation spots were below 1.5 - well within clinically acceptable thresholds in dentistry. Demonstrators included full upper dentures fabricated in shades A2, B4, and C1, as well as variants with controlled enamel translucency ranging from nearly opaque to highly translucent.

This biomimetic workflow integrates seamlessly with existing dental CAD and multi-material slicing environments.

[1] Simon, A., Chen, D., Urban, P., Duveiller, V. and Lübbe, H., Color Matching and Biomimicry for Multi-Material Dental 3D Printing. In Proceedings of the Special Interest Group on Computer Graphics and Interactive Techniques Conference, Article No.: 129, Pages 1 - 11. 2025, https://doi.org/10.1145/3721238.3730708

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COAXshield wire for DED by means of laser and wire tested by manufacturing a metal leading edge made of Ti6Al4V

© Fraunhofer IWS

COAXshield: Expanding Localized Shielding Gas Protection to Laser Wire DED and WAAM

Fraunhofer IWS has extended its proven COAXshield technology – originally developed for laser powder DED – to meet the demands in laser wire DED and wire arc additive manufacturing (WAAM). The COAXshield variants withstand the heat and specific challenges of each process and delivers shielding gas directly to the processing area. This ensures high-quality material processing without the need for costly and time consuming inert chambers. Reactive metals such as titanium, aluminum, and niobium are prone to oxidation when exposed to atmospheric oxygen during welding or deposition. This leads to brittleness, cracking, and degraded material properties. Traditional countermeasures rely on large-volume noble gas chambers, which are time-consuming to prepare and expensive to operate, particularly for large components.

COAXshield solves this challenge by fully enclosing the processing head and generating a ring-shaped shielding gas stream that maintains oxygen concentrations below 100 ppm exactly where the material is most vulnerable. This localized approach dramatically reduces inert gas consumption, minimizes setup times enabling faster iterations in development, and allows manufacturers to work flexibly with both small and very large components. The new COAXshield for laser wire DED is optimized for integration with wire-fed laser nozzles, while the COAXshield arc version fits MIG and MSG torches. These new variant make it possible to transfer the same level of shielding capabilities from powder-based systems to wire-based processes, opening new opportunities for repairs, large structural components, and rapid prototyping of reactive alloys. By eliminating the need for global inert chambers, COAXshield accelerates the development of welding and cladding processes for new materials and supports efficient manufacturing in aerospace, energy, and heavy industry.

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Newly designed divertor monoblocks from pure tungsten realized by Laser Powder Bed Fusion. © Fraunhofer ILT

Design Freedom for Fusion Reactors through Additive Manufacturing

Robust Plasma-Facing Tungsten Components to Increase Service Life

Fusion energy is among the most promising clean energy sources and a top priority in European research funding. Germany aims to have its first fusion power plant operational by 2040, but several technological challenges must be overcome to make this vision a reality.

One key challenge lies in the reactor's plasma-facing components (PFCs), such as the divertor and first-wall components. These structures are exposed to extreme cyclic heat loads of up to 20.000.000 W/m², along with intense radiation. Only one material can withstand such conditions: pure tungsten. Yet, the tungsten armor must be combined with highly conductive materials like copper or steel alloys to effectively dissipate heat.

Tungsten's exceptional hardness and brittleness limit conventional manufacturing to processes like sintering, rolling, or electrical discharge machining. These limitations restrict component geometries to simple plates or blocks.

Furthermore, joining tungsten with copper or steel alloys, typically through soldering, is challenged by mismatching thermal expansion coefficients, often leading to failure of the joints under thermal cycling.

»Additive Manufacturing of refractory metals enables fundamentally new designs of more durable fusion reactor components."

Niklas Prätzsch, M.Sc.
Fraunhofer ILT

The DURABLE project, funded by the Federal Ministry of Research, Technology and Space (BMFTR), addresses this bottleneck. In a consortium of ten partners from industry and science, researchers at Fraunhofer ILT are developing additive manufacturing (AM) strategies to manufacture monolithic multi-material components combining solid tungsten with copper or steel alloys. The technologies under investigation include Laser Powder Bed Fusion (PBF-LB/M), Directed Energy Deposition (DED-LB/M), and Extreme High-Speed Laser Material Deposition (EHLA).

By employing novel system technology and processing strategies in PBF-LB/M, the project has already achieved near crack-free, high-density tungsten parts. These breakthroughs provide engineers with a fundamentally new design freedom for plasma-facing components, allowing for conformal cooling solutions and complex geometric shapes. This will ultimately lead to more robust and maintainable fusion reactors. As a demonstrator, a PBF-LB/M manufactured W-CuCrZr divertor monoblock chain is exhibited by Fraunhofer ILT at Formnext 2025.

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Through plastic deformation, SCaRB enhances a workpiece's surface properties and residual stress distribution.

© Fraunhofer ILT

In-Situ surface and microstructure optimization via Simultaneous Coating and Roller Burnishing (SCaRB)

Innovative combination of EHLA and roller burnishing improves surface morphology, wear and corrosion resistance, as well as fatigue performance of coated parts

Extreme High-Speed Laser Material Deposition (EHLA) is recognized as a highly productive and resource-efficient advancement over conventional Laser Material Deposition (LMD), which is used for coating, repair, and additive manufacturing of components. Although EHLA achieves improved surface quality compared to LMD, mechanical post-processing of the deposited layers often remains necessary, representing a considerable time and cost constraint. In this context, the combination of additive and subtractive manufacturing processes has gained increasing attention in recent years.

A novel example of this is the Simultaneous Coating and Roller Burnishing (SCaRB) process, developed by Fraunhofer ILT, which combines EHLA with a concurrent burnishing treatment. In this approach, the roller burnishing tool interacts with the workpiece during the EHLA deposition, utilizing its residual heat to improve surface properties. By employing plastic deformation rather than material removal, this technique not only has the potential to enhance surface quality but also influences the microstructure, residual stress, and mechanical properties of the deposited and surrounding material.

This highly productive, cost- and material-efficient process combination can further enhance wear and corrosion resistance while also modifying the near-surface residual stress profile, improving fatigue performance, and inhibiting crack initiation and propagation.

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Sensor printed on a CM247 LC part manufactured by Metal Binder Jetting

Printed Electronics Meets Metal Binder Jetting of High-Temperature Nickel Alloys

How advanced printing technologies enhance production and part performance

Turning three of Additive Manufacturing's biggest buzzwords - design freedom, functional integration, and material diversity - into reality. By combining printed electronics with Metal Binder Jetting (MBJ), three industry challenges are solved in a single demonstration:

Traditional manufacturing hits its limits with complex internal structures or thin-walled designs. Sinter-based Additive Manufacturing like Metal Binder Jetting or Mold Jet (MJ) create geometries impossible via machining or casting - without sacrificing structural integrity.

The result? Parts with optimized fluid flow paths, integrated cooling channels, or lattice structures that reduce weight while maintaining mechanical performance.

Taming the Untamable

High-temperature nickel alloys like CM247 LC are notorious for their poor machinability and weldability like it´s done in LPBF. MBJ and MJ bypass these issues entirely: No welding, no supports, no tool wear. The processes enable near-net-shape production of components, where extreme heat and corrosion resistance are non-negotiable.

Smart Parts That "Talk"

Here's where printed electronics change the game. By embedding thin-film sensors directly onto the metal part, we enable real-time monitoring of:

- Temperature gradients (e.g. heat exchangers)
- Mechanical stress (e.g. predicting fatigue)
- Environmental exposure (corrosion)

These self-reporting components eliminate guesswork in maintenance, cutting downtime and extending service life. Imagine a gas turbine blade that signals its own replacement - or a reactor vessel that logs its thermal history.

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The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft, headquartered in Germany, is one of the world's leading organizations for applied research. It plays a major role in innovation by prioritizing research on cutting-edge technologies and the transfer of results to industry to strengthen Germany's industrial base and for the benefit of society as a whole. Since its founding as a nonprofit organization in 1949, Fraunhofer has held a unique position in the German research and innovation ecosystem.

With nearly 32,000 employees across 75 institutes and independent research units in Germany, Fraunhofer operates with an annual budget of €3.6 billion, €3.1 billion of which is generated by contract research — Fraunhofer's core business model.

Unlike other public research organizations, base funding from the German federal and state governments is merely the foundation for the annual research budget. This serves as the basis for groundbreaking precompetitive research that will become important for the private sector and society in the years ahead. Fraunhofer's distinctive feature is its large share of industry revenue, guaranteeing close collaboration with the private sector and industry, and the consistent focus of Fraunhofer's research on the market. In 2024, industry revenue accounted for €867 million of its budget. Fraunhofer's research portfolio is augmented by competitively acquired public-sector funding, pursuing the right balance between public-sector and industry revenue.

Driven by innovation and motivation, our team is the key to our success. At Formnext 2025, they'll showcase the future of 3D manufacturing.