Fraunhofer



News 1.26

Fraunhofer Competence Field Additive Manufacturing

Formnext 2026

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Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.
Hansastraße 27c
80686 München
www.fraunhofer.de

Project Leader
Eric Schwarzer-Fischer
eric.schwarzer-fischer@ikts.fraunhofer.de

Editing and typesetting
Fraunhofer Competence Field Additive Manufacturing
Gizemnur Hasanoglu
www.additiv.fraunhofer.de
geschaeftsstelle@additiv.fraunhofer.de

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Editorial



Welcome to Fraunhofer ADDITIV NEWS 1.26 – the formnext 2026 special issue of our Fraunhofer Competence Field Additive Manufacturing newsletter, introducing you to Fraunhofer's showcase at formnext 2026, where current highlights from Fraunhofer's applied research in Additive Manufacturing (AM) and 3D Printing are presented!

Our booth combines four major sections, clustered by AM material type – metal, polymer, ceramics and multi-material, complemented by a joint section of Fraunhofer ADDITIV that enable our visitors to get the full picture of AM – from specific AM software solutions and process simulation up to surface treatment technologies and quality management in AM.

Highlights of this year's exhibition demonstrate how functionality can be integrated directly into a component's structure via AM – please have a look at Fraunhofer CPM's ProFi Finger (in polymer) as well as Fraunhofer ILT's smart wrench with an in-situ printed strain gauge (in metal)! Other showcased functional AM structures include Fraunhofer IWU's compact 3D printed pulsating heat pipes (PHP) and Fraunhofer ILT's additively manufactured permeable structures with graded porosity. Latest material innovations showcased include Fraunhofer IKTS' additively manufactured diamond composites that combine high thermal conductivity with outstanding wear resistance. AM process innovations encompass Fraunhofer ILT's Fluidic Powder Switch for more efficient powder handling in LMD and EHLA processes, and Fraunhofer IWS' Laser Direct Plating technology. Finally, let me draw your attention to Fraunhofer IWM's FlowBoard for digital powder characterization. All together, these examples illustrate the broad potential of additive manufacturing for functional components, advanced materials, digital process development and more efficient production.

Enjoy your formnext 2026 visit and start or accelerate your AM journey with Fraunhofer ADDITIV as your gateway to Fraunhofer AM expertise – meet us in hall 11.0, at booth D31!

Dr. Bernhard Mueller
Spokesperson
Fraunhofer Competence Field Additive Manufacturing

Our Exhibitors

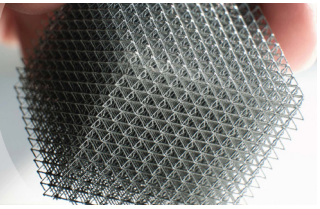
Fraunhofer Competence Field Additive Manufacturing



Office, Fraunhofer IWU, Dresden

The Fraunhofer Competence Field Additive Manufacturing integrates 19 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 Cluster of Excellence Programmable Materials CPM



Fraunhofer CPM

The Fraunhofer Cluster of Excellence Programmable Materials (CPM) comprises 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 to establishing Additive Manufacturing as a key enabler for Programmable Materials.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM



Fraunhofer IFAM, Dresden and Bremen

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 equipped additive manufacturing application center at Fraunhofer IFAM in Bremen comprises the complete process chain for PBF-LB and MBJ. At Fraunhofer IFAM in Dresden, the Innovation Center Additive Manufacturing ICAM® brings together PBF-EB, Additive Screen Printing, FFF, Gel Casting, MoldJet® and LMM under one roof.

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, Dresden

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 Institute for Laser Technology ILT



Fraunhofer ILT, Aachen

With approximately 490 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 over 40 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 and fusion technology.

Fraunhofer Institute for Manufacturing and Engineering IPA



Fraunhofer IPA, Stuttgart

Fraunhofer IPA conducts applied research in manufacturing engineering and automation. We develop, test and implement processes, components, machines and complete production systems. Combining expertise in production and automation, we work with companies of all sizes to turn research into practical solutions across a wide range of industries. Our goal is to make the production of sustainable, personalized and intelligent products economically viable. Mass Sustainability aims to minimize resource consumption while maximizing prosperity. Mass Personalization combines the efficiency of mass production with the flexibility to manufacture individualized products in batch sizes of one. We also advance biointelligent value creation, integrating biological principles with technology to make production more efficient and sustainable. In this context, we develop additive manufacturing process chains for industrial applications, with a primary focus on polymer materials.

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

DDMC2027
Fraunhofer Direct Digital Manufacturing Conference

Presentations from **Industry** welcome!

DDMC 2027 | Frankfurt am Main | Oct 27-28, 2027

Call for Papers

Timeline/ Due Dates

Call for Paper published: **November 18, 2026**
Abstract submission: **February 28, 2027**
Abstract acceptance notification: **April 15, 2027**
Paper submission: **June 15, 2027**
Paper acceptance notification: **July 31, 2027**
Conference: **October 27-28, 2027**

www.ddmc-fraunhofer.de

Contact

Fraunhofer Competence Field
Additive Manufacturing
Noethnitzer Str. 44
01187 Dresden
Germany

DDMC Conference Chairman
Dr. Bernhard Mueller
Phone + 49 351 4772-2136
office@ddmc-fraunhofer.de
www.ddmc-fraunhofer.de

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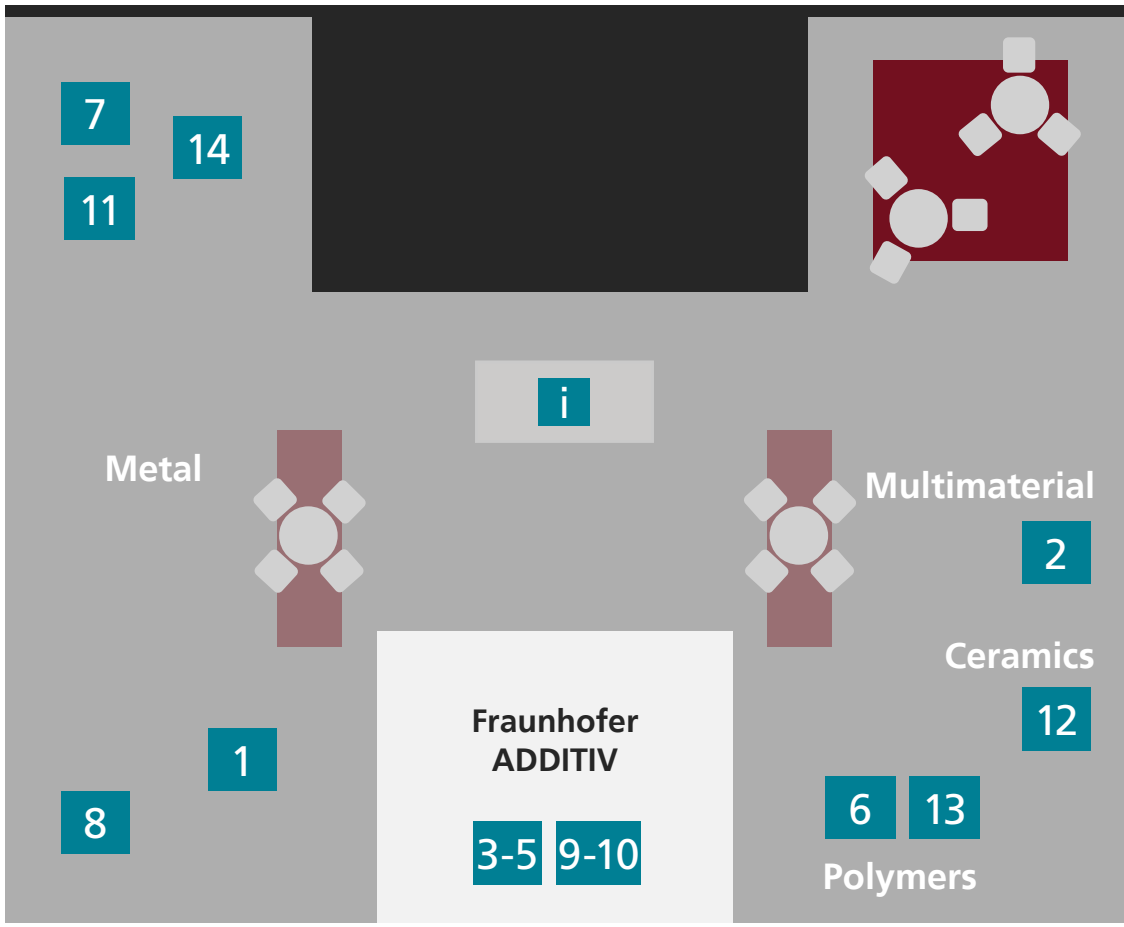
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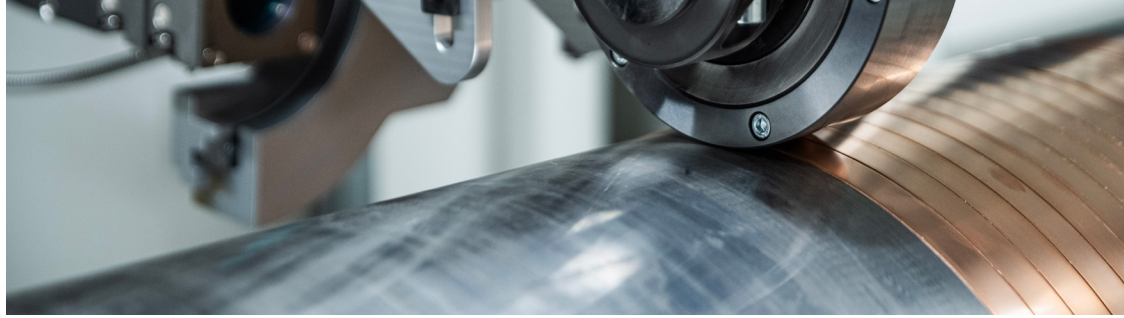


Hall 11.0, Booth D31



Pilot system for laser direct plating

© Fraunhofer IWS



© Fraunhofer IWS

Laser Direct Plating – Coating Process for Rotationally Symmetric Components

Fraunhofer IWS has developed Laser Direct Plating, an innovative coating technology for rotationally symmetric components. The process applies thick metallic coatings with significantly lower energy consumption, shorter processing times and less post-processing.

In the process, a metal strip is wound helically around the component and metallurgically bonded to the substrate using localized laser energy. Unlike laser cladding, the coating material remains largely in the solid state during joining. Precisely controlled heat input and forming force creates a dense, uniform bond while minimizing the thermal impact on the base material.

With strip speeds of several meters-per-minute, the technology achieves high deposition rates and substantially reduces production times. In one industrial application, it cut the coating time for a hydraulic cylinder theoretically from around 20 hours to approximately six hours. Depending on the application, energy consumption can decrease by up to 90 percent. Multi-layer coatings with individual layer thicknesses of one to three millimeters provide effective wear and corrosion protection and enable the targeted restoration of worn components. Combining different materials also allows manufacturers to tailor functional coatings to application-specific properties. The patent-pending process is suitable for hydraulic cylinders, plain bearings and process rolls. A pilot plant at Fraunhofer IWS is currently validating industrial applications and preparing the technology for transfer to serial production.

Fraunhofer Institute for Material and Beam Technology IWS

Dipl.-Ing. Andrea Berger
+49 351 83391-3097
andrea.berger@iws.fraunhofer.de

Tailored for Plasma: Additive Manufacturing of W-Cu Composites

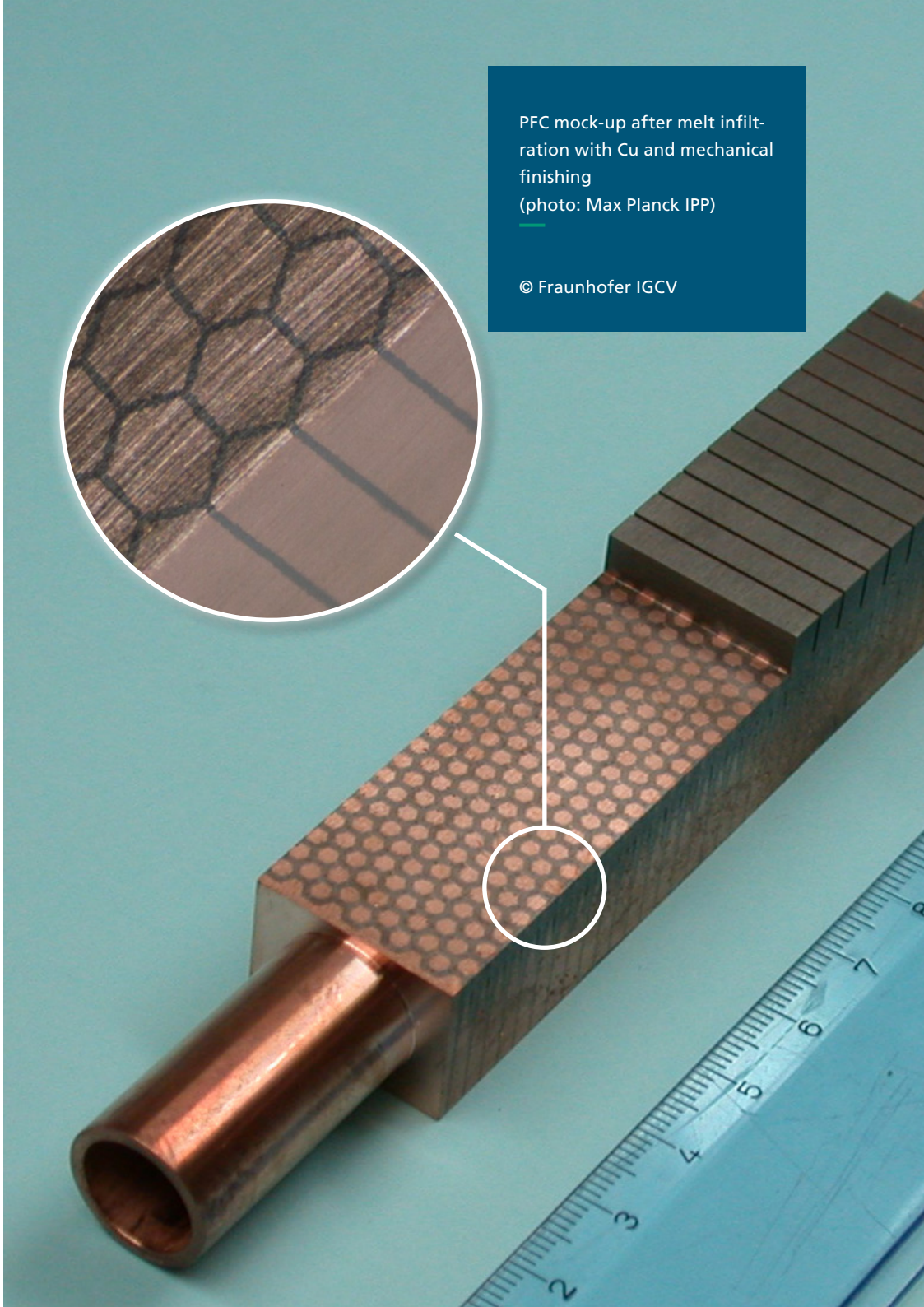
Additive manufacturing is indispensable for tailored W–Cu composites that can withstand the extreme environments of future plasma-facing components.

Plasma-facing components (PFCs) are critical to the success of future magnetic confinement fusion devices. To withstand extreme operating conditions—including steady-state heat fluxes of up to 20 MW/m², transient thermal spikes in the GW/m² range, and intense particle bombardment—the material combination of pure tungsten (W) as the armor with the copper alloy CuCr1Zr as the heat sink is the leading design choice. To overcome the limitations of conventional joining techniques, Fraunhofer IGCV in Augsburg is advancing additive manufacturing routes to realize functionally graded transitions between W and CuCr1Zr, significantly enhancing the robustness of corresponding PFC material joints.

One approach developed together with the Max Planck Institute for Plasma Physics in Garching and already validated in high-heat-flux testing leverages the design flexibility of laser-based powder bed fusion (PBF-LB/M) to fabricate open-porous, complexly shaped W structures with tapering wall thickness and internal cooling channels. These structures subsequently serve as a preform for melt infiltration with copper (Cu) alloy under vacuum, followed by mechanical finishing. By tailoring PFCs to specific operational demands, this approach delivers superior thermo-mechanical performance over extended service lifetimes—a crucial step towards the economically viable operation of future magnetic confinement fusion reactors.

Fraunhofer Institute for Casting, Composite and Processing Technology IGCV

Maximilian Bradler, M.Sc.
+49 821 90678-148
maximilian.bradler@igcv.fraunhofer.de
www.igcv.fraunhofer.de



PFC mock-up after melt infiltration with Cu and mechanical finishing
(photo: Max Planck IPP)

© Fraunhofer IGCV



© German Orbital Systems GmbH (Satellite) and GettyImages / fotograzia (background)

Functional components using shape memory polymer

1U CubeSat equipped with shape memory polymer hinges for active deployment

© Fraunhofer IAP

Lightweight satellite components enabled by a high-temperature switching shape memory polymer

The rapid growth of the NewSpace sector is driving demand for lightweight, functional satellite components. Reducing their mass while maintaining functionality and eliminating parts of the underlying electromechanical systems creates valuable capacity for additional mission-critical payloads.

Shape memory polymers (SMPs) are smart materials that can retain a temporary shape after programming and recover their original shape upon heating.

Fraunhofer IAP is collaborating with German Orbital Systems (GOS), Orion Additive Manufacturing, and Fraunhofer IZM within the Pro FIT funding program. Fraunhofer IAP developed an application-specific SMP with a switching temperature of approximately 120 °C and qualified it for additive manufacturing.

In collaboration with GOS, the team utilized the SMP to produce 3D-printed solar-panel hinges, employing two heating wire configurations: an integrated internal design and a circumferentially wrapped one. The weight of each hinge including the wires is about 1.5 g. Resistive heating activates the shape memory whereupon the SMP changes shape and aligns thsse solar panels so that they reach their target position.

These lightweight, additively manufactured hinges combine structural and deployment functions, reducing reliance on conventional electromechanical systems and enabling more efficient satellite designs.

Fraunhofer Institute for Applied Polymer Research IAP

Dr. Thorsten Pretsch
+49 331 568-1414
thorsten.pretsch@iap.fraunhofer.de
www.iap.fraunhofer.de

Non-destructive testing of AM parts with certified computed tomography

High-resolution digitization and metrology for dimensional testing and defect analysis

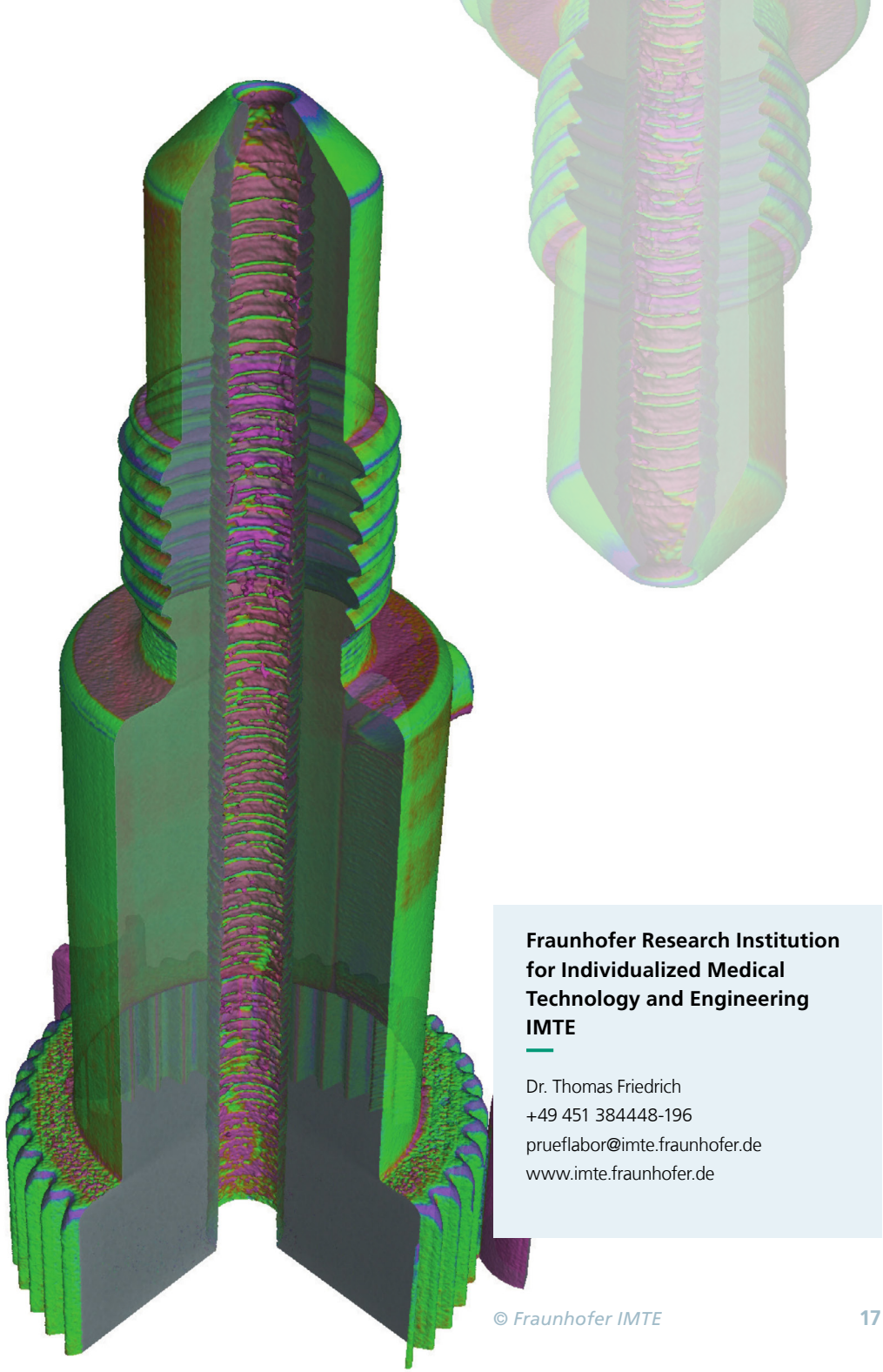
At Fraunhofer IMTE, accredited high-resolution industrial computed tomography is used for the in-depth analysis of complex parts with a focus on the specific needs for additively manufactured components.

Fraunhofer IMTE provides reliable measurement and testing services for additively manufactured components, including implants, prostheses and patient-specific devices.

Accredited by the German Accreditation Body (DAkkS) in accordance with DIN EN ISO/IEC 17025, the testing laboratory delivers reliable and traceable test results. The accreditation confirms its technical competence and supports the assessment of safety, quality and reproducibility – critical requirements in medical additive manufacturing, where even minor deviations may affect patient safety. The testing laboratory enables precise component evaluation and provides a robust basis for quality assurance throughout development and application. Its services support companies and research institutions in transferring innovative technologies into safe and economically viable medical and industrial practice. Fraunhofer IMTE also facilitates the development of custom testing procedures.

CT-based analysis enables the precise determination of form, dimensions and positional deviations, as well as the assessment of internal and external defects without harming the object, hence non-destructive testing. This is particularly relevant for 3D-printed components, where complex geometries and manufacturing-related imperfections can significantly affect quality and safety.

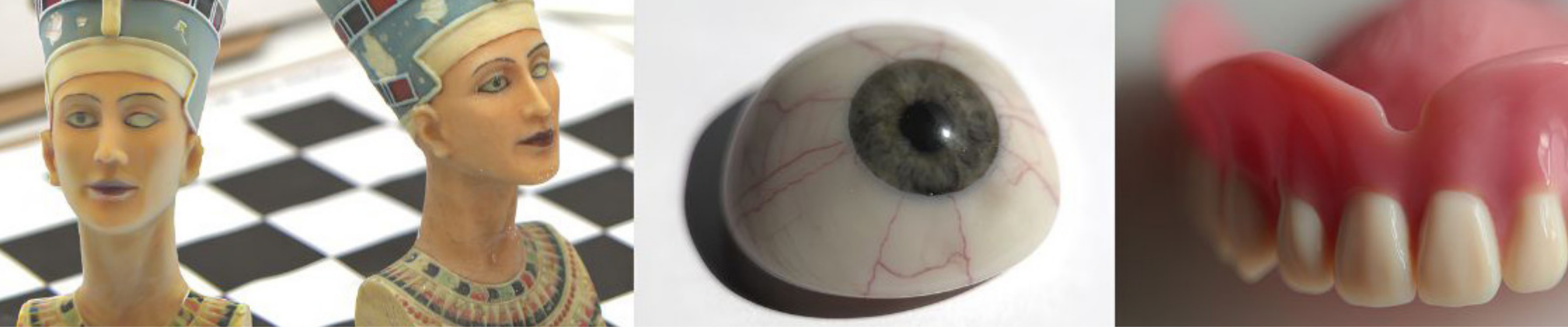
As part of Fraunhofer IMTE's innovation and transfer infrastructure, the accredited testing laboratory helps accelerate the implementation of personalised medical technology.



Fraunhofer Research Institution for Individualized Medical Technology and Engineering IMTE

Dr. Thomas Friedrich
+49 451 384448-196
prueflabor@imte.fraunhofer.de
www.imte.fraunhofer.de

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Cuttlefish® and data-driven design software for multi-material 3D printing

Tools for high-quality appearance reproduction

Cuttlefish® delivers high-quality appearance reproduction in multi-material 3D printing. Its software ecosystem combines precise color and translucency control, predictive visualization, improved surface quality, and data-driven design tools for efficient, adapted production.

Multi-material inkjet 3D printing places different materials voxel by voxel, making it possible to reproduce color, translucency and internal structure in a single print. At the core of a software ecosystem that turns this capability into usable products is our 3D printer driver Cuttlefish®. It controls various printing systems and material sets, translating a digital model into a voxel-level material arrangement, reproducing spatially varying color and translucency, and removing staircase artifacts.

This core continues to evolve and expand, including new support for the Mimaki 3DUJ-2207 as well as new color and translucency profiles. It is also being adapted to other printing technologies, with experimental support for wax jetting and binder jetting, where its shape dithering removes staircase artifacts to improve surface quality.

Around this core, Cuttlefish:: Proof shows what a design will look like before anything is printed. The physically based renderer simulates how light interacts with the printed materials, including spectral absorption and scattering, to predict the final appearance under defined viewing and illumination conditions, reducing trial-and-error, material use and production time. Specialized export from Blender and 3DS Max feed this review loop: users export textured models directly into Cuttlefish, to quickly review and prepare 3D-printing projects.

Further out, two data-driven design tools generate print-ready models directly from CAD and patient data. Cuttlefish::Tooth prepares dental CAD geometries in two steps: internal geometries are automatically inserted into the tooth geometries of the denture model, then multi-material mixtures are assigned to these layers to reproduce the selected dental shade, including its color and translucency. Cuttlefish:: Eye automatically creates a custom ocular prosthesis model from optical image data. Using color characterized images and the high color accuracy of Cuttlefish, this produces prostheses that closely match the color and appearance of the patient's real eye. Over 200 patients have been supplied with a prosthesis created this way.

Fraunhofer Institute for Computer Graphics Research IGD

Alan Brunton, Ph.D.
alan.brunton@igd.fraunhofer.de
www.igd.fraunhofer.de
www.cuttlefish.de



Tool-free EPDM spare-part seal produced by material extrusion. © Fraunhofer IPA

3D-Printed Seals: New Freedom in Materials, Geometry and Function

Tool-Free Solutions for Customized Components

Does every geometry change require a new tool? Fraunhofer IPA develops additive processes for the manufacturing of customized seals and for depositing sealing structures directly onto components. This enables tool-free production from batch size one and new solutions for spare parts, variants and functionally integrated components.

Conventional production is economical at high volumes, yet tooling costs and lead times can be substantial for prototypes, obsolete parts and customized geometries. Additive manufacturing (AM) can compensate for these disadvantages while offering further benefits: seal design can follow application requirements rather than manufacturing constraints. Geometries can be adapted to uneven surfaces, produced on demand or printed directly onto housings, semi-finished parts and flexible substrates.

Three AM process routes cover different material classes. In **material extrusion**, Fraunhofer IPA processes vulcanizable elastomers such as EPDM, NBR and FFKM. One example is the tool-free production of EPDM spare-part seals using the original material.

Additive manufacturing allows seal design to follow application requirements rather than manufacturing constraints. «

Oliver Refle,
Fraunhofer IPA

Fluid material extrusion is used for highly viscous pastes, thermosets, elastomers and one- or two-component silicones. The process accommodates viscosities from 1 to 1,000,000 mPa s and materials ranging from soft elastomers to rigid polymers. Multi-material deposition enables locally tailored properties and opportunities for integrating sensors or actuators.

Material jetting and inkjet printing enable the precise deposition of highly viscous UV- or thermally curable photopolymers onto semi-finished components. Droplet-based deposition supports fine geometries, locally varied hardness and functional gradients.

Fraunhofer IPA supports the complete development route: material scouting, rheology and printability testing, process parameterization, module and machine development, design for additive manufacturing and application-oriented qualification. Testing can also address the leak tightness of additively manufactured housings, channels and fluid-carrying parts. These results provide a sound basis for material selection, component design and process optimization.

Meet our experts at Formnext 2026 and discuss your sealing application:
hall 11.0, booth D31

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Dipl.-Ing. Oliver Refle
+49 (0) 711 – 970-1867
Oliver.Refle@ipa.fraunhofer.de
www.ipa.fraunhofer.de



Integrated strain gauge in additively manufactured wrench. © Fraunhofer ILT

Everybody is looking for additive sensors, but we are missing robust and efficient processes and suitable materials. «

Dr. Samuel Fink,
Fraunhofer ILT

Additive Sensor Fabrication in PBF Parts

Making additive parts smarter

Powder Bed Fusion (PBF-LB/M) combined with digital printing technologies enables monolithic, load-monitored components. Fraunhofer ILT demonstrates in-situ strain gauge integration, embedding functional sensor layers directly inside metal structures to capture mechanical loads during operation.

During the additive manufacturing of metallic components via Powder Bed Fusion, the layer-by-layer build cycle provides transient access to internal cross-sections. Fraunhofer ILT leverages this process window to fabricate fully integrated sensor systems. By combining PBF with precision printing techniques like aerosol-jet printing and dispensing technologies, functional layers – such as dielectrics and conductive tracks - are directly deposited onto internal surfaces.

At Formnext 2026, we highlight this capability with a functional demonstrator: a smart wrench featuring an in-situ printed strain gauge. As the tool is operated under load, the embedded sensor measures real-time mechanical deformation and stress distribution directly within the component. This in-situ fabrication approach overcomes the limitations of conventional surface-mounted sensors, which are vulnerable to mechanical abrasion, thermal degradation, and harsh environments. Encapsulating the sensor within the metallic matrix protects the sensitive functional layers while positioning the transducer directly in the principal load path. This enables highly accurate load monitoring, structural health monitoring (SHM), and predictive maintenance for mission-critical applications.

We use a hybrid PBF machine that allows for the targeted removal of metal powder from cavities and is equipped with dispensing and aerosol-jet printheads. With this setup, complex geometries can be fabricated without interrupting the process.

Fraunhofer ILT sees great potential in the possibility to add other functional materials into PBF-parts besides electronics, such as heat-resistant layers, optical fibres or design elements. Visit us at Formnext 2026 in Frankfurt to try our smart wrench demonstrator yourself and discuss tailored additive sensor solutions for your industrial requirements.

Fraunhofer Institute for Laser Technology ILT

Dr. Samuel Moritz Fink
+49 241 8906-624
samuel.fink@ilt.fraunhofer.de



Printed injection nozzle made of In713c by MoldJet

© Fraunhofer IFAM

Beyond Laser: Rethinking Nickel Superalloy Production

How sinter-based processes open the door to notoriously difficult alloys

Overcoming limits for Nickel alloys

Nickel-based superalloys are the backbone of high-temperature engineering. Wherever heat, pressure, and corrosion meet at once, these materials are hard to replace. CM247 LC and IN713C are exemplary for this kind of alloys. Both are proven high-performance materials, but both share a well-known drawback. Their poor weldability makes them a tough match for laser-based additive processes like PBF-LB, where cracking and residual stress often get in the way.

Sintering instead of melting

Fraunhofer IFAM uses a way around this: Sinter-based process routes using Metal Binder Jetting, MoldJet or LMM. No melt pool, no welding, none of the typical issues that come with laser-based metal AM. The results speak for themselves. CM247 LC delivers high strength not only at room temperature, but also at 700 °C, with values exceeding 950 MPa.

New opportunities in materials

What does this mean in practice? Components made from notoriously hard-to-weld nickel alloys can now be additively manufactured without compromising mechanical performance. Right where conventional AM processes reach their limits, the sinter-based route picks up the slack. The same principle applies far beyond nickel superalloys. Tool steels like M2 and H13, both notoriously difficult to weld, can now be processed the same way, opening the door to a much broader range of demanding materials.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

Dr.-Ing. Thomas Studnitzky
+49 351 2537-339
Thomas.studnitzky@ifam-dd.fraunhofer.de
www.ifam-dd.fraunhofer.de



© Fraunhofer IWM

FlowBoard – Digital Powder Characterization for Predictive Additive Manufacturing

Experimental characterization of powders and automated calibration of material models for powder-based AM processes

Powder-based additive manufacturing processes such as Laser Powder Bed Fusion (LPBF) strongly depend on the flow behavior of the applied powder. Flowability, cohesion and particle interactions influence powder spreading, layer homogeneity and, consequently, the quality and reproducibility of manufactured components.

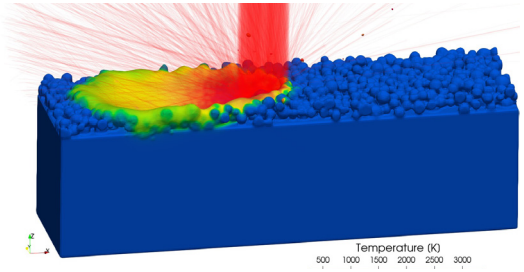


Figure 1: LPBF simulation using SimPARTIX

At Fraunhofer IWM, these processes are investigated using particle-based simulations to better understand and optimize powder handling during additive manufacturing.

Reliable simulations, however, require accurate material models. While particle-based simulations provide sophisticated contact and particle interaction models, their predictive capability is only as good as the underlying material parameters. The experimental determination and calibration of these parameters therefore represent a crucial prerequisite for realistic simulations of powder-based AM processes.

FlowBoard – Powder Characterization for Particle-based AM Simulations

To address this challenge, the "Powder Technology and Particle Simulation" group at Fraunhofer IWM has developed the FlowBoard, an experimental platform for the comprehensive characterization of powder flow behavior. Instead of analyzing individual powder properties, the FlowBoard combines several characteristic flow scenarios into a single, freely configurable obstacle course. During an experiment, the powder passes through a defined sequence of geometric structures while an automated optical system continuously records its flow behavior. This enables the simultaneous evaluation of multiple flow properties that are of great importance for the calibration of simulation models.

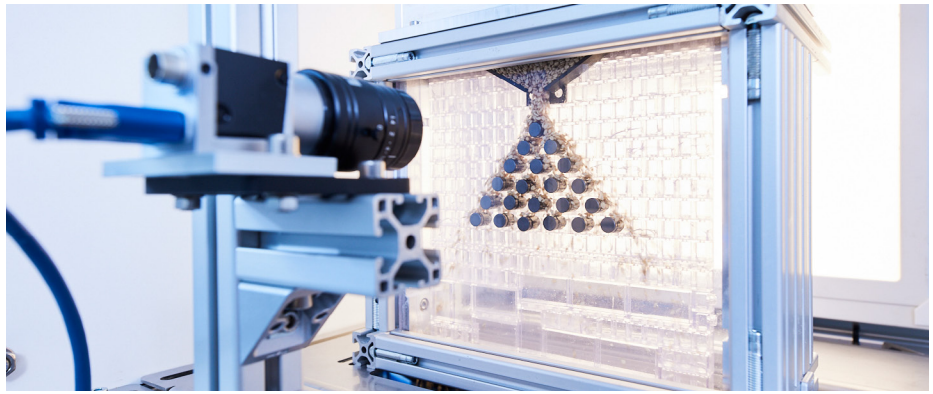


Figure 2: FlowBoard laboratory setup. © Kai-Uwe Wudtke , Fraunhofer IWM

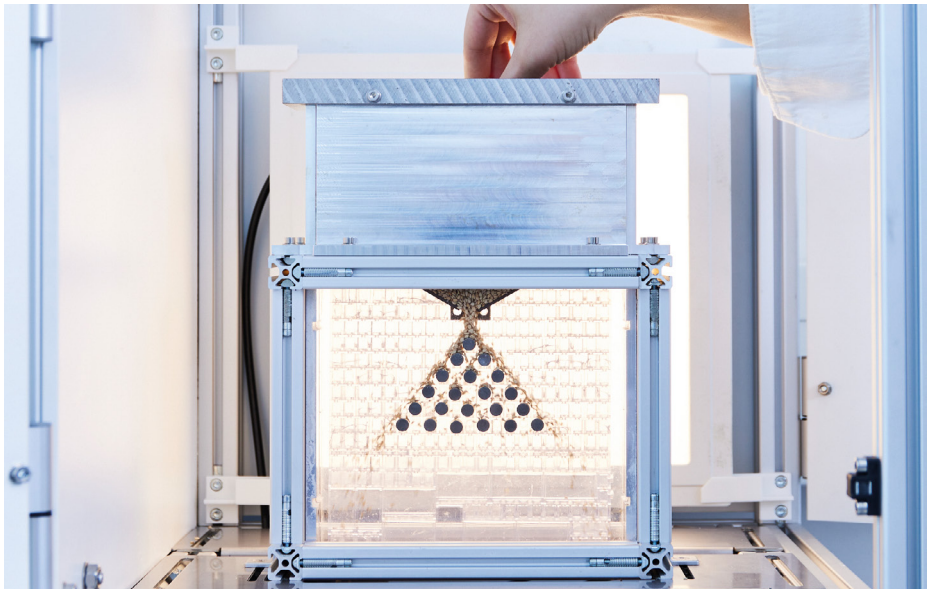


Figure 3: Complete characterization of the powder flow through an obstacle course. © Kai-Uwe Wudtke , Fraunhofer IWM

The resulting experimental data serve as the basis for determining the material model parameters. While some parameters can be obtained directly from the measurements, others are determined through inverse modeling by comparing experimental observations with particle simulations. The model parameters are iteratively adjusted until the simulated powder reproduces the experimentally observed flow behavior with high accuracy.

This systematic calibration approach yields reliable, material-specific parameter sets that can be used in different simulation scenarios.

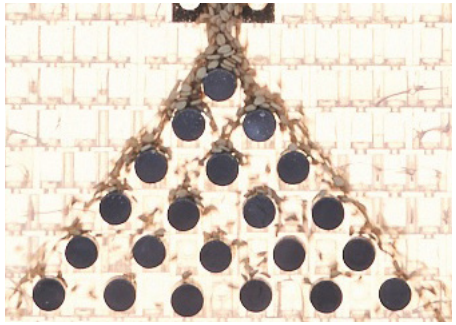


Figure 4: Detailed view of flow pattern. © Kai-Uwe Wudtke , Fraunhofer IWM

From Powder Characterization to Predictive AM Simulation

The calibrated material models enable realistic simulations of powder spreading, powder transport and other particle-based phenomena that are essential for powder-bed additive manufacturing. This provides valuable insights into process behavior before costly experimental trials are carried out, supports process optimization and increases the predictive capability of digital process models.

By linking experimental characterization with physics-based particle simulation, the FlowBoard establishes the foundation for reliable virtual process development and digital twins in additive manufacturing, helping industry accelerate material qualification, reduce development effort and improve process robustness.

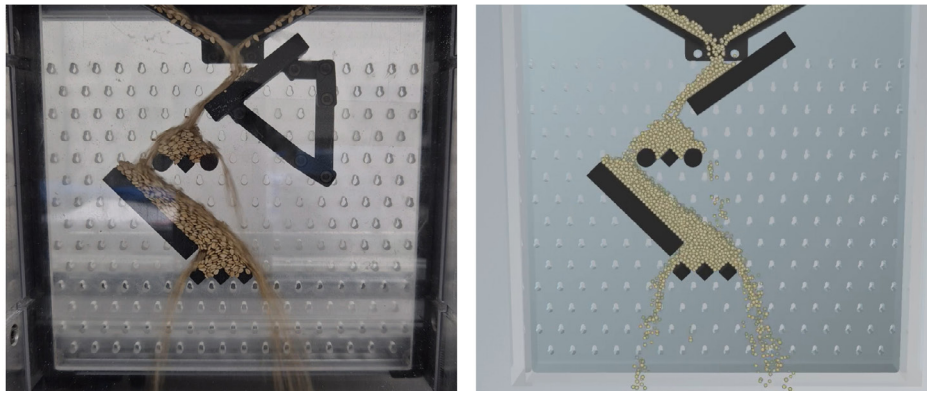


Figure 5: Exemplary FlowBoard analysis. Experiment (left); Simulation (right). © Fraunhofer IWM

Fraunhofer Institute for Mechanics of Materials IWM

Dr. Claas Bierwisch
+49 761 5142-347
claas.bierwisch@iwm.fraunhofer.de
www.iwm.fraunhofer.de

3D-printed pulsating heat pipes inside compact systems

Lightweight and powerful: Additive manufacturing for high-performance cooling

As electronic components become more powerful and densely packed, heat removal in limited spaces becomes more challenging. Additively manufactured pulsating heat pipes (PHPs) offer one solution: inside their narrow, meandering channels, alternating liquid and vapor segments oscillate between hot and cold sides, transporting heat in minimal space. Unlike conventionally manufactured PHPs, which require machined channels and precisely joined plates, 3D printing creates the base body and internal channels as a single monolithic part.

This reduces manufacturing steps and opens up extensive design freedom. Application-specific geometries, curves and bends can be tailored to the available installation space, while additional cooling channels can be integrated directly into housings, structural components or cooling systems. Initial copper demonstrators produced by Fraunhofer IWU and Fraunhofer IPM prove the technology's potential. With an effective channel area of approximately 170 × 90 mm, a height of only 2.8 mm and a weight of around 150 g, they dissipated about 1,200 W in preliminary vertical and horizontal tests. Depending on design and operating conditions, several kilowatts may be achievable.

The institutes support customers from feasibility assessment and customized design through demonstrator production, filling, quality control and thermal validation to production scale-up.

Fraunhofer Institute for Machine Tools and Forming Technology IWU

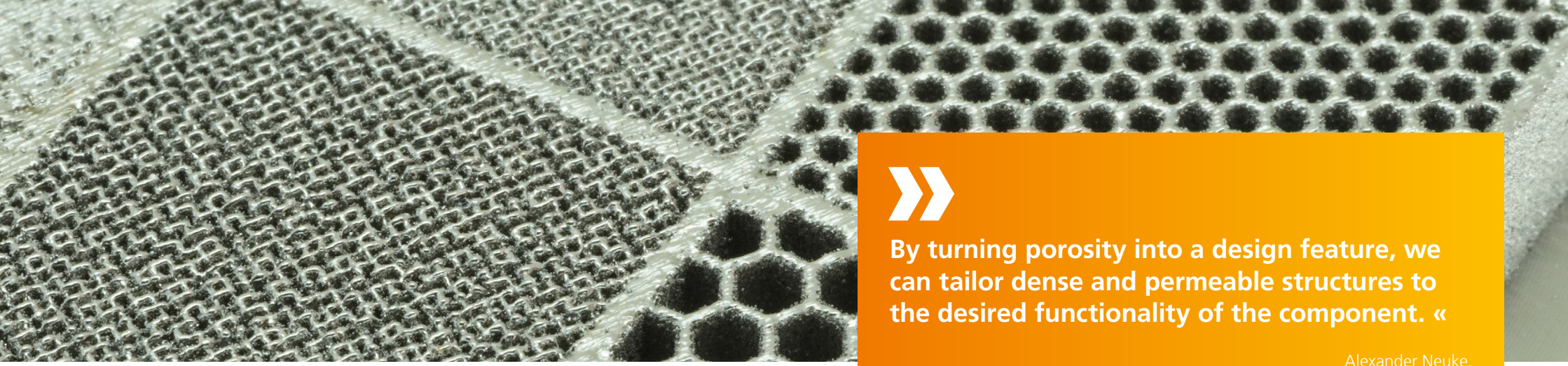
Nikolaus Milaev, M. Sc.
nikolaus.milaev@iwu.fraunhofer.de
www.additiv.fraunhofer.de





3D-Printed pulsating heat pipes inside compact systems

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> **By turning porosity into a design feature, we can tailor dense and permeable structures to the desired functionality of the component. «**
>
> Alexander Neuke,
> Fraunhofer ILT

Additive Manufacturing of permeable structures

Graded permeability for electrolysis cell

Permeability in metal components is conventionally realized with metal foams, meshes or sintered filters. These are manufactured separately and joined to the component, which costs time, limits design freedom and increases thermal and electrical resistances at every interface.

Permeability as a design feature

Researchers at Fraunhofer ILT use Laser Powder Bed Fusion (PBF-LB/M) to create controlled porosity. While the process has so far been optimized for maximum density, controlled local porosity turns permeability into a designable feature.

Two mechanisms are combined:

- Geometric pores: defined in the design, for coarse and reproducible channels
- Stochastic pores: from adapted process parameters, for fine filter-like structures

Dense and permeable zones can thus be integrated within a single part, with sharp or graded transitions in one monolithic component. No post-processing is required to add these structures. This unlocks entirely new geometric freedom, enabling complex internal channels and contours in a single build.

Use Case: The Electrolysis Cell

Electrolyzer stacks consist of numerous functional layers, among them the porous transport layer (PTL), which feeds water to the membrane, remove product gases, conduct electricity and provide mechanical support. These conflicting requirements demand different porosities across the layer thickness, conventionally achieved by stacking sintered fleeces and meshes.

In the LPBFCells project, funded by the Federal Ministry for Economic Affairs and Energy (BMWE), Fraunhofer ILT manufactures the PTL in a single PBF-LB/M build with graded porosity: the coarse, membrane-distant region through geometric pore design, the fine, membrane-facing region through adapted process parameters.

The benefits:

- One part instead of a stack of sintered layers
- Lower contact resistances without joints
- Flow field and support structure integrated monolithically
- Fast iteration of cell geometries and porosity profiles

Beyond electrolysis, the approach is of interest for tooling, turbomachinery and filters. As a demonstrator, an electrolysis cell stack with a PBF-LB/M manufactured, graded PTL manufactured from pure Titanium grade 1 is exhibited by Fraunhofer ILT.

Fraunhofer Institute for Laser Technology ILT

Alexander Neuke, M.Sc.
+49 241 8906-630
alexander.neuke@ilt.fraunhofer.de
www.ilt.fraunhofer.de



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» A material that can handle anything. «

Christian Berger,
Fraunhofer IKTS

Figure 2: A dense microstructure consisting of diamond (dark grey), silicon carbide (grey) and residual silicon (light grey). The phase constituents are distributed homogeneously. The microstructure has a low residual silicon content.
Figure 1: Furthermore a complex curved tube made of diamond composite.
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Diamond composite, a material of superlatives

Properties of the Material:

Diamond is the hardest known material. Machining it is therefore particularly challenging. By processing diamond-based composites, unique properties can be achieved. The composite consists of diamonds, silicon carbide and a small proportion of silicon. With a thermal conductivity of up to 600 W/K·m (copper = 400 W/K·m) and, at the same time, increased wear resistance compared to boron carbide, the material exhibits unique properties.

Due to its high hardness, post-processing is effectively impossible. Conversely, this means that components must be manufactured as close as possible to their final contours. This is precisely where additive manufacturing comes into its own.

Additive Manufacturing of Diamond Composites:

This has already been impressively demonstrated using the binder jetting and fused filament fabrication processes. Appropriate feedstocks were developed for both processes. These feedstocks, developed at the IKTS, were processed on standard commercial machines. The manufactured components were subsequently pyrolysed. During this process, the organic components are decomposed. Liquid silicon is infiltrated into the open pore network. In the process, the free carbon is converted into secondary silicon carbide, which further increases the carbide content. The result is a dense microstructure (see figure), consisting of over 50 % diamond.

The IKTS demonstrates the successful development and feasibility of such exceptional materials.

Application of Diamond Composites:

The combination of complex geometries and unique properties is utilised, for example, in heat transfer – such as in heat exchangers – and in wear resistance, for instance in wear protection.

Fraunhofer Institute for Ceramic Technologies and System IKTS

Dipl-Ing. Christian Berger
+49 351 2553-7815
christian.berger@ikts.fraunhofer.de



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What if a component carried its function within its very structure? «

ProFi-Finger: One Component, multiple Stable Positions

A showcase of Programmable Materials by CPM

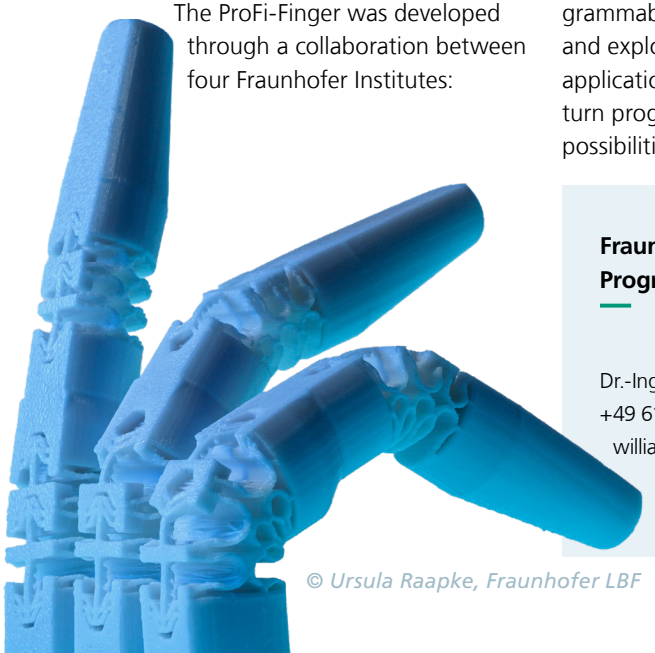
The Fraunhofer Cluster of Excellence Programmable Materials (CPM) brings together expertise from materials science, engineering, simulation and additive manufacturing to explore a new generation of functional materials. By precisely combining material, geometry and structure, mechanical properties and movements can be deliberately programmed - opening up new possibilities for additive manufacturing.

One example is the ProFi-Finger, which brings this principle to life. Developed for a passive hand prosthesis, it replaces a conventional finger joint consisting of multiple individual parts with a single additively manufactured component. This is made possible by a programmable metamaterial with a bistable structure: the finger can assume several defined, stable positions – without additional joints, springs or screws.

The ProFi-Finger demonstrates how function can be directly integrated into the material structure. The targeted design of bistable unit cells enables both movement and stability. At the same time, the demonstrator highlights the potential of additive manufacturing for such complex structures: geometries that would be difficult or require multiple parts to produce using conventional manufacturing methods can be manufactured as one integrated component.

The ProFi-Finger was developed through a collaboration between four Fraunhofer Institutes: IWM led the project and developed the bista ble unit cells, Fraunhofer LBF developed the hinge structure and Fraunhofer ITWM supported the development with the "ProgMatCode" simulation software, and Fraunhofer IAP carried out the additive manufacturing.

Discover the ProFi-Finger and other programmable materials at the CPM booth and explore what they could do for your applications. Talk to our experts and turn programmable materials into new possibilities!



© Ursula Raapke, Fraunhofer LBF

Fraunhofer Cluster of Excellence Programmable Materials CPM

Dr.-Ing. William Kaal
+49 615 1705-440
william.kaal@lbf.fraunhofer.de



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Every gram of powder recovered saves costs, protects the component, and conserves resources. «

Viktor Glushych,
Fraunhofer ILT

Powder On, Powder Off – Switching in Milliseconds

Fluidic Powder Switch for LMD and EHLA

Metal powder is one of the main cost drivers in Laser Material Deposition (LMD) and its high-speed variant EHLA. During idle times, however, a considerable amount of powder flows through the system unused. Fraunhofer ILT's Fluidic Powder Switch stops the powder flow directly at the nozzle – without moving parts and with virtually no wear.

Although modern powder nozzles can achieve material efficiencies above 90 percent, overall powder efficiency also depends on machine efficiency. In processes with complex tool path planning, such as turbine blade repair or highly dynamic EHLA3D, efficiency drops because powder continues to flow even when the laser is off. This causes material losses, contamination, quality problems, and risks to equipment and occupational safety.

Conventional systems switch the powder mechanically. Because of system inertia and the distance between the switch and process zone, switching times often exceed one second. Abrasive powder also causes wear, requiring regular maintenance of the system. For dynamic LMD and EHLA processes with frequent short cycles, the current solution is simply too slow and uneconomical.

The novel Fluidic Powder Switch works differently: it redirects the powder directly at the nozzle using the Venturi principle. A control gas creates negative pressure in a constricted cross-section and draws the powder into a collection container instead of the process zone. Compressed air, argon, or nitrogen can be used. With no moving components in the powder path, the patented system is virtually wear-free and requires little to no maintenance.

Beyond simple on/off switching, the system can toggle between multiple materials and adjust the powder mass flow rate in steps. Because it acts directly at the nozzle, switching is ten to twenty times faster than with mechanical systems, allowing even short laser-off periods to be used for savings.

The economic benefit further increases with higher mass flow rates and shorter cycle times typical for mass production. Every avoided second of unnecessary powder flow reduces costs immediately. The switch is therefore particularly attractive for series production and is already in successful industrial use.

Fraunhofer Institute for Laser Technology ILT

Viktor Glushych, M.Sc.
+49 241 8906-152
viktor.glushych@ilt.fraunhofer.de
www.ilt.fraunhofer.de

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 31,000 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 2025, industry revenue accounted for €966 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 2026, we showcase the future of 3D manufacturing.