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Formnext 2023

News 1.23

Fraunhofer Competence Field
Additive Manufacturing

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Editorial

Welcome to the hot of the press issue of the formnext special edition of NEWS 1.23 – the newsletter of the Fraunhofer Competence Field Additive Manufacturing, showing the highlight exhibits of the Fraunhofer joint booth at formnext 2023!

For the first time, the new booth concept, which divides the booth into four sections along the process chain from pre-process operations, via in- and post-process to recycling shall make it easier for visitors to explore our booth on their own. Moreover, the exhibits are clustered according to their material. The main showcase at the entrance of the walk along the additive value chain introduces the process-chain in its entirety with the example of the FingerKIt project. Our cover picture shows the implant itself, while the article at pages 10 –13 describes the project in detail. Thus, patient-specific implants, produced by additive manufacturing, allow a new treatment perspective for impaired finger joints. Furthermore, Fraunhofer IWMS gives insights into recyclates powder production, while 3D printed parts for a modular robotic vehicle by LPBF have been realized in a consortium between EDAG, Constellium and Fraunhofer IWU. But there is much more to explore in this newsletter, we hope you enjouy reading and learning more about Fraunhofer's formnext exhibits!

Please also note that the call for papers for Fraunhofer DDMC 2025, which will take place on March 12 and 13, 2025, is now officially open! Feel free to submit your abstract on our website!
We wish you a successful formnext 2023 trade fair visit and look forward to a lively exchange with you directly at formnext at our booth in hall 11.0, booth D31!

Dr. Bernhard Mueller
Spokesperson
Fraunhofer Competence Field Additive Manufacturing

Editorial

Our Exhibitors

Office, Fraunhofer IWU, Dresden

Fraunhofer Competence Field Additive Manufacturing

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 IWS, Dresden

Fraunhofer Institute for Material and Beam Technology IWS

Materials and Lasers – Competence with a System. At Fraunhofer IWS, we stand for applied research. In cooperation with our partners, we develop innovative and resource-efficient solutions with materials, lasers, and systems.

Fraunhofer IGCV, Augsburg

Fraunhofer Institute for Casting, Composite and Processing Technology IGCV

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 AMLab, where we conduct research on various processes, e.g. laser-based powder bed fusion of metals (PBF-LB/M), multi-material processing, cold spray for additive manufacturing, liquid metal printing and metal 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

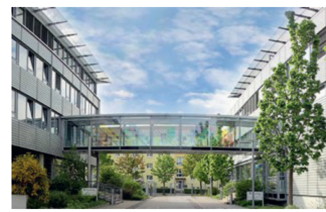
Fraunhofer Institute for Machine Tools and Forming Technology IWU

The Fraunhofer IWU is a driver for innovations in the research and development of production engineering. Around 670 highly qualified employees work at our locations in Chemnitz, Dresden, Leipzig, Wolfsburg, and Zittau. We open up the potential for competitive manufacturing in automotive and mechanical engineering, aerospace technology, medical engineering, electrical engineering, and precision and microengineering. We focus on scientific developments and contract research regarding components, processes, methods, and the associated complex machine systems and their interaction with humans – the entire factory. As the leading institute for resource-efficient manufacturing, we bank on highly flexible, scalable cognitive production systems using nature as an example.

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 equipped additive manufacturing application center at Fraunhofer IFAM in Bremen comprises the complete process chain for PBF-LB and MBJ[2]. At Fraunhofer IFAM in Dresden, the Innovation Center Additive Manufacturing ICAM® brings together PBF_EB, 3D Screen Printing, FFF[4], Gel Casting, MoldJet® and LMM[5] under one roof.



Fraunhofer IFAM, Dresden and Bremen

Fraunhofer Institute for Laser Technology ILT

Fraunhofer ILT, Aachen

Activities of Fraunhofer ILT cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modelling and simulation as well as in the entire system technology. We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines.

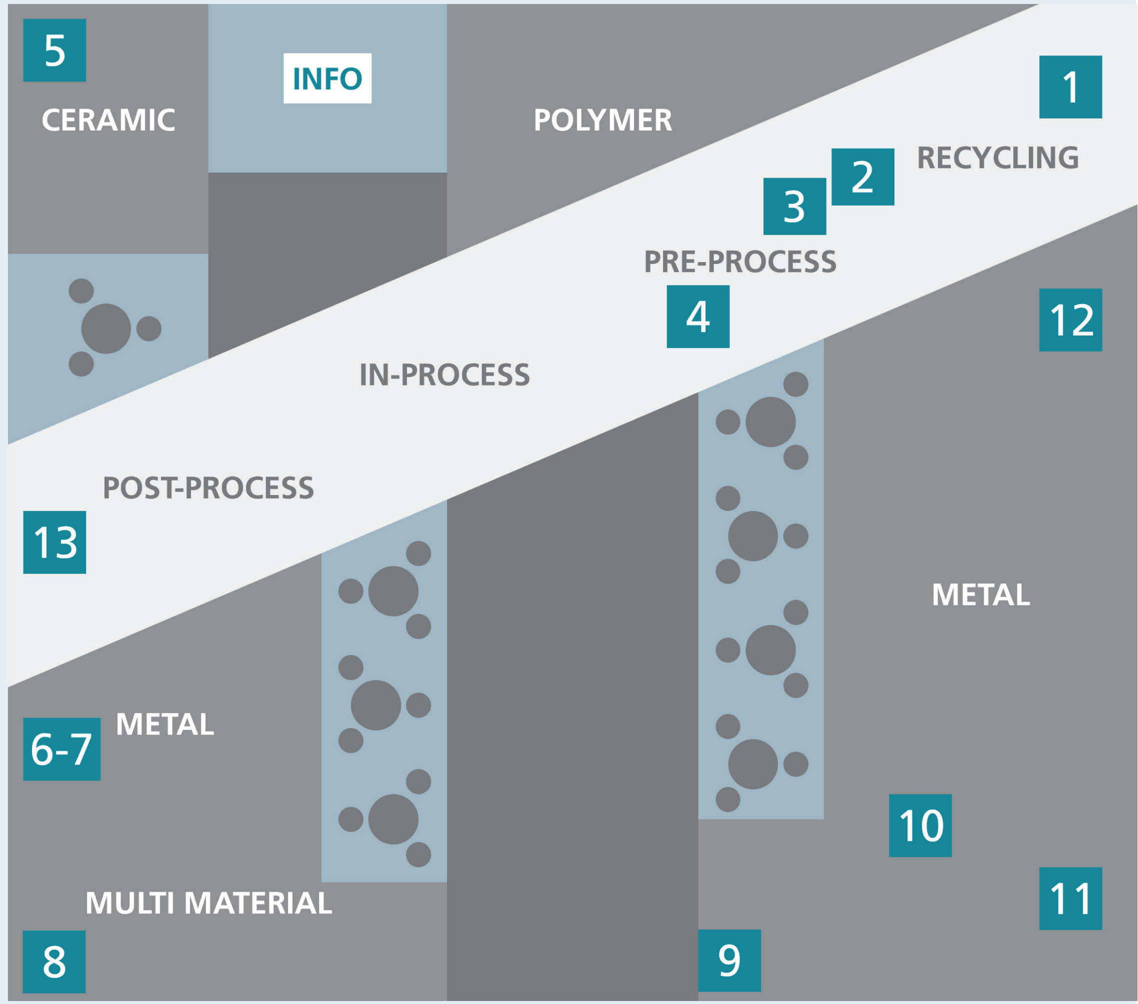
Fraunhofer Group for Production

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 2023, the special focus will be on presenting process developments in the field of function integration and a wide variety of post-processing methods.

1 LBM: Laser Beam Melting
2 MBJ: Metal Binder Jetting
3 SEBM: Selcetive Electron Beam Melting
4 FFF: Fused Filamemt Fabrication
5 LMM: Lithography-based Metal Manufacturing

Content



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Ceramic and Titanium implant variants developed in the FingerKIt project

Patient-specific implants made by AM – a new treatment perspective for impaired finger joints

Remobilization of finger joints through AI-based reconstruction

Patient-specific implants promise a high accuracy of fit and thus better functionality and durability than conventional implants. Furthermore, individualization is a great opportunity for areas in which the possibilities of implant fitting and remobilization are still insufficient, e.g. for small joints such as finger joints.

In the internal Fraunhofer project FigerKIt, an autonomous process chain in the production of patient-specific implants has been developed for the first time, from design and production to certification-compliant testing. With Fraunhofer IAPT, IKTS, ITEM, IWM and MEVIS, five institutes were working on this joint project. The potential of metal binder jetting for the production of high-precision components comes to bear in the manufacture of the filigree finger implants.

Development of shape models from imaging data

Based on clinical 2D X-Ray scans and 3D CT-scans, Fraunhofer MEVIS developed a method to generate a 3D shape model of the fingers, which is the starting point for the implant design process. The goal was to use only 2D X-Ray data in order to reduce time, cost and patient risk by avoiding the necessity of CT scans.

> **»**
> **Through FingerKIt, the prospect of restoring the mobility of impaired finger joints can become a reality for patients. «**
>
> **Dr.-Ing. Philipp Imgrund**
> **Fraunhofer IAPT**

AI-based design automation of personalized implants

At Fraunhofer IAPT, developing a suitable design of the implants and automating the design process was addressed. Based on X-Ray data and predefined requirements from the shape models, an algorithm has been trained to generate the patient-specific implant design fully automatically. One main asset is the integration of filigree automatically generated TPMS structures in the shaft for reliable osseointegration, providing a firm fit and preventing implant loosening.

At Fraunhofer IWM, the biomechanical parameterization of the implant design was performed based on simulations. This allows for optimized simulations and the generation of a model for reliability prediction. Additionally, different concepts for certification-compliant testing of the mechanical properties of small artificial joints were evaluated.

Fraunhofer Research Institution for Additive Manufacturing Technologies IAPT

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Finger model with integrated ceramic implants

Additive and near-net-shape production

In addition to developing the designs, Fraunhofer IAPT has also adapted the metal binder jetting technology for a titanium alloy for precise manufacturing of the filigree implants. Appropriate printing and sintering parameters have been developed to assure reproducible quality and biocompatibility. In parallel, Fraunhofer IKTS has developed an additive manufacturing process chain for complex silicon nitride implants with triply periodic minimal surface (TPMS) structures, high density and good biocompatibility. Additionally, slip cast alumina-toughened zirconia (ATZ) prototypes feature an osseointegrative macro/micro surface texturing of the stem. Due to near-net-shape manufacturing, no further hard machining is necessary, except for the articulating surface. The high quality of the microstructure results in mechanical properties that far exceed the loads that occur in the implanted state.

Biocompatibility testing and regulatory documentation

Fraunhofer ITEM was in charge of the biocompatibility testing and development of a novel push-out test method for verification of the bone ingrowth into the implant. In addition, ITEM developed a full regulatory ISO 13485-conform documentation for the patient-adapted implant.

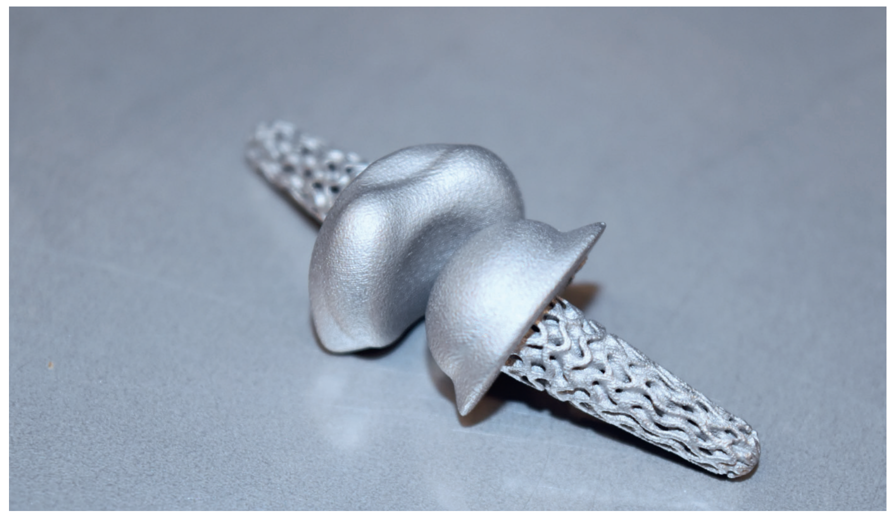
Outlook:

In follow-up projects, the partners seek to establish a proof of concept for manufacturing of AI generated individual small joint implants made of ceramics or titanium in collaboration with industry, standardization bodies and hospitals, in order to established patient specific finger joint implants in the market. Moreover, the work flow may be transferred to other small patient-specific implants.

Key results of the FingerKit project

- 3D shape models derived from 2D X-Ray data for simplified defect imaging
- Biomechanical simulation and reliability prediction of the 3D-printed implants
- Automated implant design process based on 3D imaging data of the defects
- AM processes for implants made of Titanium, oxide and nitride ceramics
- Biological and mechanical characterization and full regulatory documentation

Titanium implant with TPMS structured shaft for enhanced osseointegration



Powder production of functional materials from recyclates.

@ Fraunhofer IWKS

Recyclate powders of functional materials for additive manufacturing

Functional materials show intrinsic properties such as magnetism or special transport properties needed for various applications, e.g. magnets, thermoelectrics. Additive manufacturing of these materials has not been well established yet, however, a resource-efficient near-net-shape production technique could revolutionize device geometries and open the way for new applications.

Fraunhofer IWKS specializes in the synthesis of permanent magnets such as Nd-Fe-B magnets and magnet recycling from electronic engines or other devices. Over the last years, the department Magnetic Materials, led by Jürgen Gassmann, has established a close collaboration with research groups at Technische Universität Darmstadt (recently with Additive Manufacturing Center) to produce permanent magnets via different techniques of additive manufacturing. The challenge is not only to produce a dense material, but to achieve the right microstructure for optimal magnetic properties, too.

The Attract research group "green²ICT", led by Dr. Sebastian Klemenz, aims to combine expertise in recycling functional materials with resource-efficient production including additive manufacturing (selective laser melting). The group works on intermetallic phases as e.g. thermoelectrics for local cooling and waste energy harvest.

For more insights into recyclate powder production and additive manufacturing of functional materials, please contact Jürgen Gassmann or Dr. Sebastian Klemenz, respectively.

Fraunhofer Institute for Materials Recycling and Resource Strategies IWKS

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Virtual process-structure-property relations

Multiphysics simulation of powder bed fusion

A simulation chain has been developed for laser-beam powder bed fusion for metals (PBF-LB/M), starting with powder layer application, laser melting and microstructure formation, and ending with the estimation of certain local mechanical properties of the processed material. The entire workflow is summarized in Figure 1.

Laser ray tracing and melt pool simulation

The interaction of the laser with the metal is modelled by raytracing, which makes it possible to describe multiple reflections of a beam at the material surface. The dynamics of the melt pool depend on various temperature-dependent physical properties, such as surface tension, viscosity, heat capacity, and thermal conductivity. A suitable tool for comprehensive modeling of the complex physics is the Smoothed Particle Hydrodynamics method (cf. Figure 2). In the simulations, it can be determined, for example, whether given laser parameters lead to a process in conduction mode or in keyhole mode.

Microstructure formation and mechanical properties

The temporal and spatial temperature profiles are used as input variables for a Cellular Automaton simulation that predicts the metallic microstructure. Microstructure here refers to the size, shape, and orientation of the dendritic grains formed after the material resolidifies in the melt pool. The solidification process is determined by a competition between grain nucleation and grain growth. The predicted microstructure is used as input for a final simulation step where the finite element method is used to calculate directional mechanical properties, such as Young's modulus, using a crystal plasticity model.

In summary, the presented chain of models and simulation methods using the software tools SimPARTIX® and VirtualLab from the Fraunhofer IWM can be used to study the PBF-LB/M process with a high level of detail. This does not completely replace corresponding experiments but opens up new avenues for a deep understanding of process-structure-property relationships. This enables both process and component optimization for existing material systems and the development of new alloys for the PBF-LB/M process.

Virtual process-structure-property relations

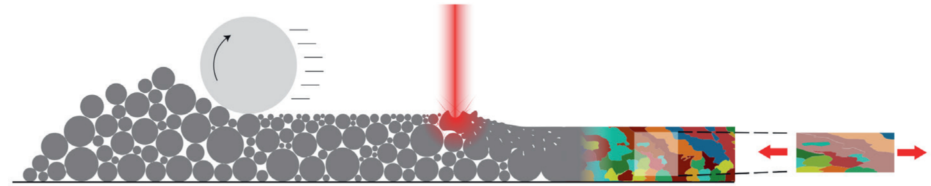

Figure 1: Simulation chain for modeling the PBF-LB/M process

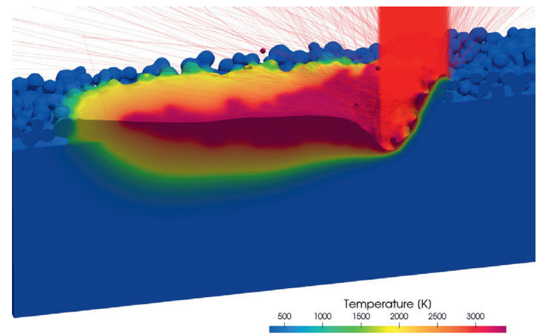

Figure 2: PBF-LB/M ray tracing melt pool simulation of Ti6Al4V with color-coded temperature

PBF-LB/M simulations for

- process parameter identification
- enhanced part properties
- accelerated material development

Fraunhofer Institute for Mechanics of Materials IWM

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Personalized cartilage and tendon implants

> This advancement is expected to facilitate faster and more effective regeneration of damaged orthopedic soft tissues. «
>
> Dr. Achim Weber
> Fraunhofer IGB

3D bioprinting using modified biomaterials

Combination of biomaterials and 3D bioprinting

Tendon, ligament, and cartilage injuries resulting from aging or athletic activities are prevalent health issues globally. Yet they are often underestimated as contributors to long-term disability, reduced quality of life, and increased healthcare expenses. Although both surgical and non-surgical treatments are available, they come with extended recovery periods, fail to fully restore the natural biological and mechanical functions of the tissues, and may lead to complications due to foreign materials. This result in complex requirements for the 3D bioprinting ink processed during bioprinting, since it must be biocompatible on the one hand, and on the other hand, it should have suitable properties (viscosity, surface tension) for the printing process and determine the material properties of the printed tissue equivalent. To tackle these challenges the effective combination of biomaterials, cells, and 3D bioprinting techniques offers a promising solution to overcome the limitations observed in clinical trials when using simple hydrogen scaffolds.

Photocrosslinkable and 3D bioprintable scaffolds

The approach aims to replicate the native extracellular environment of orthopaedic soft tissues, thus providing patients with a long-term less invasive and more efficient method to treat these injuries.

In order to replicate the biochemical and mechanical characteristics of healthy cartilage and tendon structures, we developed 3D bioprintable scaffolds using methacrylated biomaterials. These modified biomaterials offer the advantage of flexibility in adjusting the stiffness of the hydrogel scaffolds through the process of photopolymerization. Additionally, they exhibit excellent printability and enable the fabrication of patient-specific, temporally, and spatially controlled multi-layered hydrogel scaffolds.

Outlook: Better and faster regeneration

We have the capability to adjust the stiffness levels of our hydrogels, allowing us to closely replicate the mechanical properties of native tissues. In addition, these 3D printable biomaterials create a porous matrix that facilitates the incorporation of cells and growth factors. Consequently, by enhancing these hydrogel scaffolds with the addition of cells and nanoencapsulated regenerative factors, we anticipate to significantly improve cell growth and differentiation.

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

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> **»Additively manufactured ceramics are now, for the first time, a real alternative to components made of polymers and metals, especially for applications in harsh environments.«**
>
> Dr.-Ing. Uwe Scheithauer
> Fraunhofer IKTS

CerAMfacturing: Hybrid processing of advanced ceramics and beyond

Advanced ceramics have combinations of properties that other classes of materials cannot achieve. They are characterized by very high thermal, chemical and mechanical resistance and usually also have a lower density than metals.

By adapting additive manufacturing processes for advanced ceramics (CerAM), ceramic components can be complexly shaped, further functionalized and miniaturized – as is common for other classes of materials. As a result, highly complex ceramic components can be produced economically, with post-processing reduced or even eliminated. Additively manufactured ceramics are now, for the first time, a real alternative to components made of polymers and metals, especially for applications in harsh environments.

Multimaterial and -functional components

In order to meet the ever-increasing demands for the functionalization and miniaturization of components, it is necessary to combine different materials. Property combinations such as dense/porous or electrically or thermally conductive and insulating enable the production of parts with previously unattained properties. AM technologies based on thermoplastic binder systems, in which the materials are applied only at the points at which they are needed, are particularly suitable for the production of multimaterial and -functional components. These technologies also offer the chance to process an almost unlimited materials portfolio. The possibilities extend beyond technical ceramics: metals, hard metals, glasses, composites, cermets and even polymers can be processed.

Commercialization of Multi Material Jetting by AMAREA Technology GmbH

Multi Material Jetting (CerAM MMJ) is a droplet-based AM technology developed at Fraunhofer IKTS that enables the manufacturing of components from one or more materials simultaneously by fusing individual thermoplastic droplets. Highly particle-filled thermoplastic feedstocks are deposited in the molten state. The technology is currently being commercialized within the framework of an EXIST research grant project (03EFQSN180) by BMWK. The spin-off AMAREA Technology GmbH enters the market as system provider for Multi Material Jetting printers and associated printing materials and services.
(Hall 12.1, Booth B39A)

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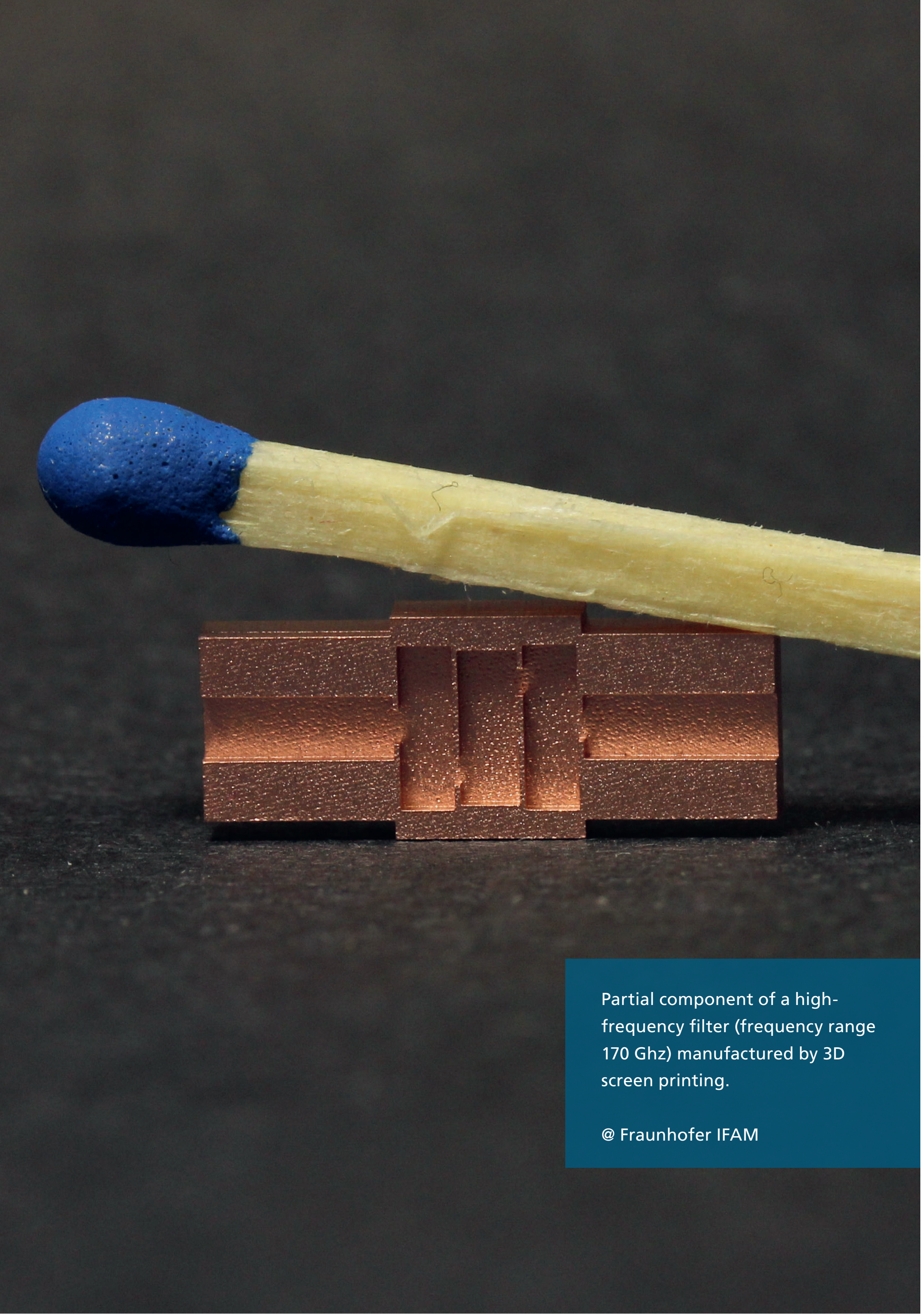

Partial component of a high-frequency filter (frequency range 170 Ghz) manufactured by 3D screen printing.

@ Fraunhofer IFAM

Additive manufacturing of copper for 5G, 6G and beyond

Applications of high frequency components include current and future communication systems (mobile and satellite communication) as well as radar and sensor applications. Near field communication in the upcoming 5G and 6G mobile communication standards is also intended to have a center frequency in the millimeter wave frequency range. Conventionally produced (i.e. milled) components are manufactured successively one after the other and lead to very bulky antenna-feed sub-assemblies that may not comply with mass and envelope requirements. Further, the necessary tolerances for the realization of low-loss and well-matched parts are very tight. Not only is conventional manufacturing of these components cost- and time-intensive, but it is also critical from an environmental perspective due to material waste during milling.

Special Additive Manufacturing technologies can be the solution. At Fraunhofer IFAM, the 3D screen printing and lithography-based metal manufacturing (LMM) processes have been further developed to enable the production of both high-resolution and complex copper structures.

Both processes allow structure resolutions of less than 100 µm with very high surface qualities. Not only complex internal geometries can be realized, but also quantities of several million units are possible in a subsequent application. Thus, Fraunhofer IFAM is making a valuable contribution to modern high-frequency communication, which is finding ever wider application in the networked globalized world.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

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Screen printed Fe-6.5Si sheets in motor geometry.

@ Fraunhofer IFAM

Additive Manufacturing – a novel approach for soft magnetic components

The energy efficiency of electric motors depends, among other factors, on losses in their ferromagnetic cores. Today, the common approach is to stack laminated sheets of Fe-3 wt-% Si with thin insulating layers. While Fe-6.5 wt-% Si has been shown to exhibit superior magnetic performance, its application has been hampered by its poor workability. In addition, the sheet stacking limits the feasible geometries. For mobility applications especially, high specific power and small unit volume are desirable.

At Fraunhofer IFAM in Dresden, this challenge is addressed via Additive Manufacturing in two ways. On the one hand, developments in 3D screen printing make it possible to circumvent processing difficulties with Fe-6.5 wt.-% Si by producing intricate thin layers for sheet stacking. Measured coercive field strengths resulted in low values of 25 A/m.

On the other hand, electron beam melting (PBF-EB), which is suitable for crack-prone materials especially, resulted in high-density material. Magnetic characterization of toroidal samples revealed coercivity of up to 7 A/m, which was previously unattainable. Together with the geometric freedom and the possibility to manipulate microstructures, this allows completely new approaches for tailoring the shape of the soft-magnetic core.

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additive_manufacturing

Multi-material additive manufacturing for space applications – Aerospike

Efficient engines for rockets have been developed since the 1960s. A functional Aerospike engine offers a performance increase of up to 20% over conventional engines. However, the concept has not been implemented for the use in launchers due to the technical challenges that could not be overcome with conventional design and manufacturing methods. Especially, the problems with overheating in the spike have not been solved until today.

Multi-material additive manufacturing allows the realization of new approaches:

An aerospike engine developed by LEAP71 using computational engineering was manufactured by the Fraunhofer Institute for Casting, Composite and Processing Technology IGCV from two different materials by powder bed fusion using a laser beam. In cooperation with Nikon SLM Solutions AG, Fraunhofer IGCV has developed a dual-metal application mechanism for the SLM 280 HL system, which enables the production of multi-material components. Targeted material distributions in each voxel of the component, functional integrations, and a complex design can be obtained.

High-temperature areas of the engine are made of copper with heat-conductive connections to less overheated areas. Segments of the aerospike with structural loads are fabricated from high-strength steel. The copper ribs on the outside serve as both cooling elements and structural elements.

Fraunhofer Institute for Casting, Composite and Processing Technology IGCV

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Strain gauges were integrated in a cutter head during the printing process. Left: The LPBF printing process is interrupted, and the printed strain gauges are fitted. Right: The printing process is continued to complete the intelligent component. © Fraunhofer IKTS

Seamless integration of sensors during the additive manufacturing process

Since the mid-1990s, the Fraunhofer Institute for Laser Technology ILT has been driving additive manufacturing (AM) forward, especially of metallic components. Because AM offers numerous advantages for various industries, it has become a key technology in this field: It enables this industry to produce complex engine parts, structural components and spare parts at lower weight and significantly reduced life-cycle costs.

To collect sufficient information about machine and component conditions, Fraunhofer ILT has developed a pioneering sensor infrastructure for aerospace as well as industrial applications. With this infrastructure, sensors can be automatically printed on a component surface; they can register the smallest deformations in the µm range, as well as temperature and vibrations. Sensors for sensing light or identify gases or liquids are also possible.

»The sensor registers the smallest cracks that occur before they lead to component failure,« explains Samuel Fink, Group Leader Thin Film Processing at Fraunhofer ILT. Since the sensors provide real-time data, they make predictive maintenance possible. By combining structural and functional printing with laser-based post-processing, the institute can integrate sensors directly into components while they are being produced. This not only makes is easier to precisely place sensors, but also protects them against harsh environmental conditions in industrial use as well as in space.

»

Integrated sensors allow battery cells to be monitored individually and improve processes in mechanical and plant engineering.«

Samuel Fink
Fraunhofer ILT

In addition to production, AM processes are also playing an increasingly important role in maintenance, repair, and overhaul. For this reason, Fraunhofer ILT researchers have developed an automated, hybrid process chain to repair metallic components both sustainably and efficiently. They have combined mechanical processing with extreme high-speed laser material deposition EHLA in a single processing step.

On the one hand, the combination of the EHLA process with pre- and post-processing significantly increases productivity. On the other, the coating materials have only a fraction of the hardness, due to the high temperature from the EHLA process, compared to the cooled material. The tool thus wears significantly less and at the same time works faster.

Fraunhofer Institute for Laser Technology ILT

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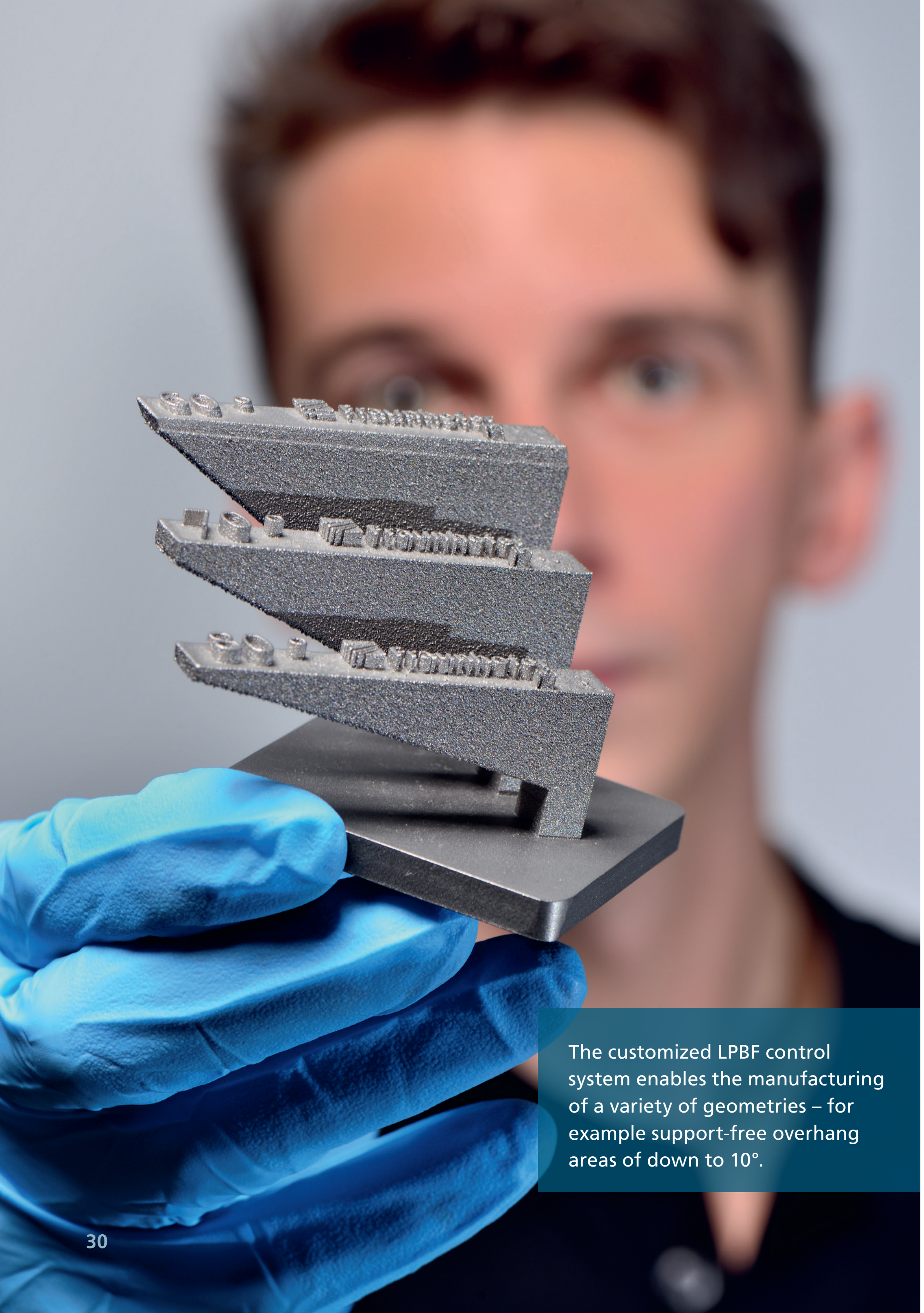

The customized LPBF control system enables the manufacturing of a variety of geometries – for example support-free overhang areas of down to 10°.

Tailored Laser Powder Bed Fusion

Geometry- and application-adapted LPBF process control opens up new possibilities for additive manufacturing

In Laser Powder Bed Fusion (LPBF), geometrically complex components are manufactured by remelting powdered material layer by layer. After applying a powder layer, the laser beam is moved across the areas of the powder bed that should be remolten according to a predefined processing strategy consisting of scan sequence and process parameters. However, the geometric characteristics of the component are currently only taken into account to a minor extent when selecting the processing strategy: This strategy is determined for the entire component, so that, for example, filigree and solid component areas are processed with the same strategy. This results in shape deviations, component distortion and restrictions in surface quality and productivity. In addition, the user has little influence on the quality of the component surface

At Fraunhofer ILT, a customized LPBF process control system is being developed which takes into account the component geometry to be manufactured and the user's requirements. To enable this, the necessary modifications are being made to the system and control technology to enable the LPBF process parameters to be controllable down to the level of individual scan vectors. Furthermore, software for component analysis was developed to enable geometry-specific assignment of the process parameters.

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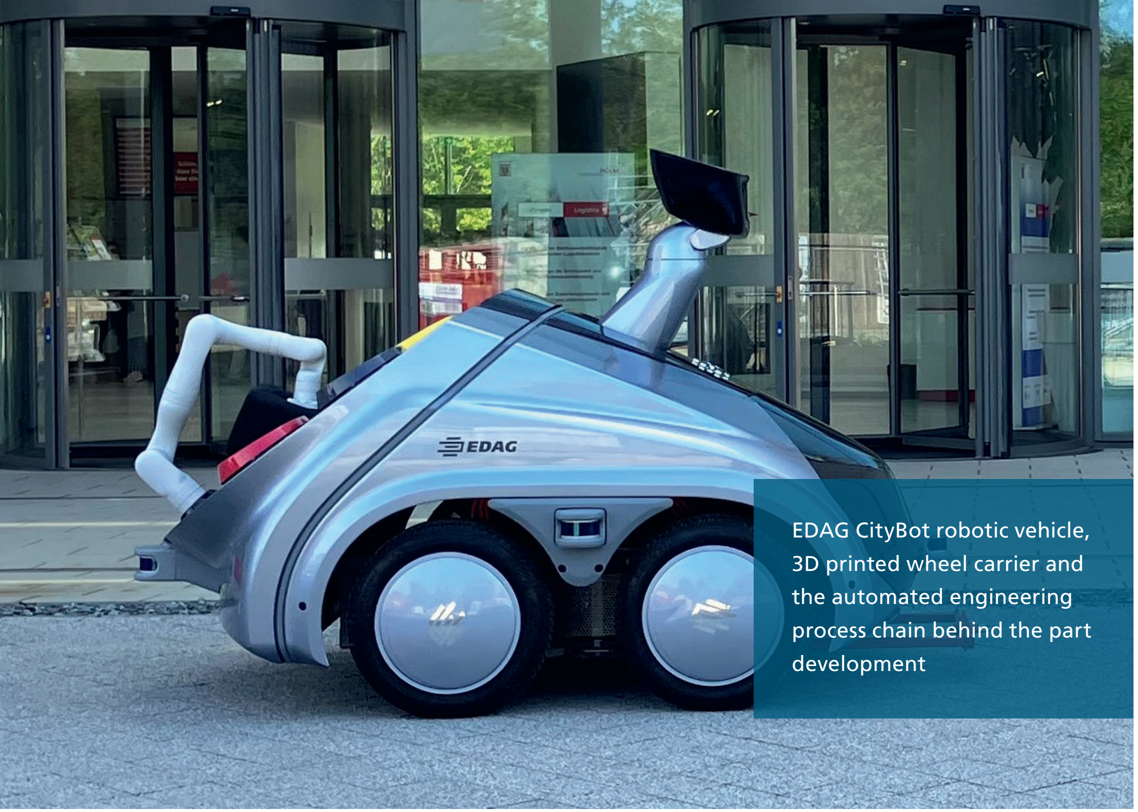
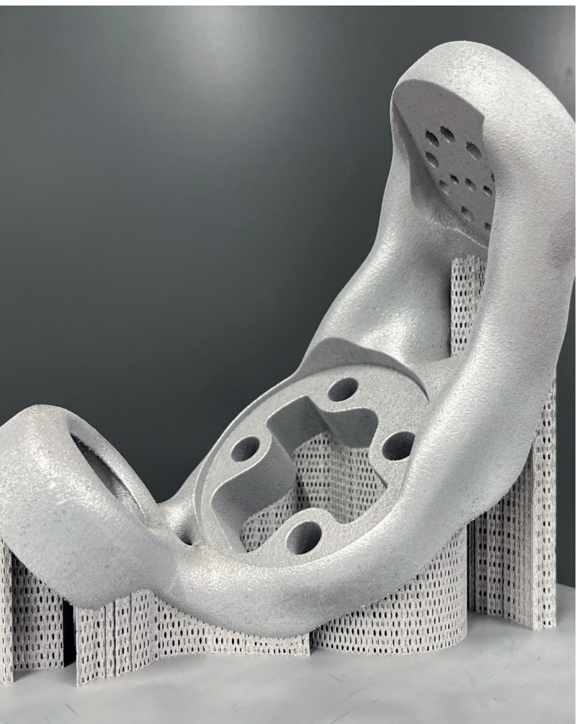
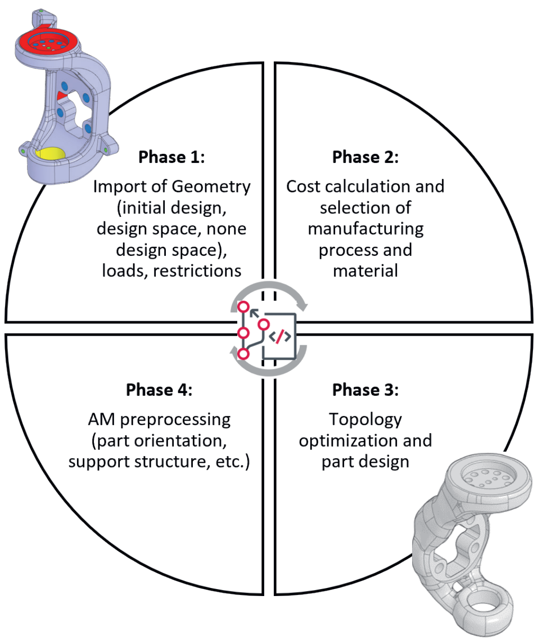


EDAG CityBot robotic vehicle, 3D printed wheel carrier and the automated engineering process chain behind the part development

EDAG Constellium Fraunhofer IWU





3D printed parts for a modular robotic vehicle realized by LPBF in Aheadd® CP1

EDAG, Constellium and Fraunhofer IWU cooperate for an economic manufacturing of automobile parts

The EDAG CityBot, part of the Campus FreeCity project, is a multifunctional robotic vehicle that can be flexibly adapted to the transportation task by means of a towing vehicle and variable add-on modules (passenger transport, cleaning tasks, etc.).

EDAG, Constellium and Fraunhofer IWU have developed a process chain for rapid component development and selection of the most suitable manufacturing process and material. The wheel carrier component of the CityBot was chosen as a demonstrator. It is a multifunctional load-bearing component that connects the chassis with the wheel and steering motors. Different transportation tasks and corresponding loads require a flexible and fast adaptation of the part design.

Laser Powder Bed Fusion (LPBF) in combination with Constellium Aheadd® CP1, an aluminum alloy specially developed for the LPBF process, has proven to offer economic and technological advantages. It offers maximum flexibility for the given requirements in terms of very good processability, high and robust mechanical properties (UTS > 300 MPa, A > 10 %) and highly productive processing (> 60 cm^3/h per laser). Fraunhofer IWU developed the LPBF process parameters for the industrial LPBF system TRUMPF TruPrint 5000.

In the coming months, the components will be tested and analyzed in detail under real conditions in a living laboratory at the Deutsche Bank Park in Frankfurt.

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Plant integrated measurement

The LIsec powder nozzle measurement system measures powder flows after leaving the nozzle.

»LIsec« lights the powder flow

A measuring system for automated characterisation of the powder nozzle during laser powder build-up welding

Increased process reproducibility through tool measurement

While tool calibration is state of the art in conventionally used ablative processes such as milling, in laser powder buildup welding it is still a great challenge. The Fraunhofer Institute for Material and Beam Technology IWS developed the measuring device "LIsec" to solve this challenge and to move the limits to technical feasibility. The abbreviation stands for "Light Section" and already reveals the principle: A measuring laser scans the powder flow after leaving the nozzle. A right-angled camera records light sections through the powder and forwards them to an analysis software. The three-dimensional distribution of the powder flow can be calculated with high precision. This allows significantly simplified quality control and provides information on the wear degree of the powder nozzle.

For example, it can be used to repair damaged or worn turbine blades on aircraft in higher quality and more reliably than before. In this respect, the measuring device can contribute to greater safety and lower maintenance costs in aviation. The Dresden institute is already working on the industrial implementation of the technology with several well-known international companies and research institutes.

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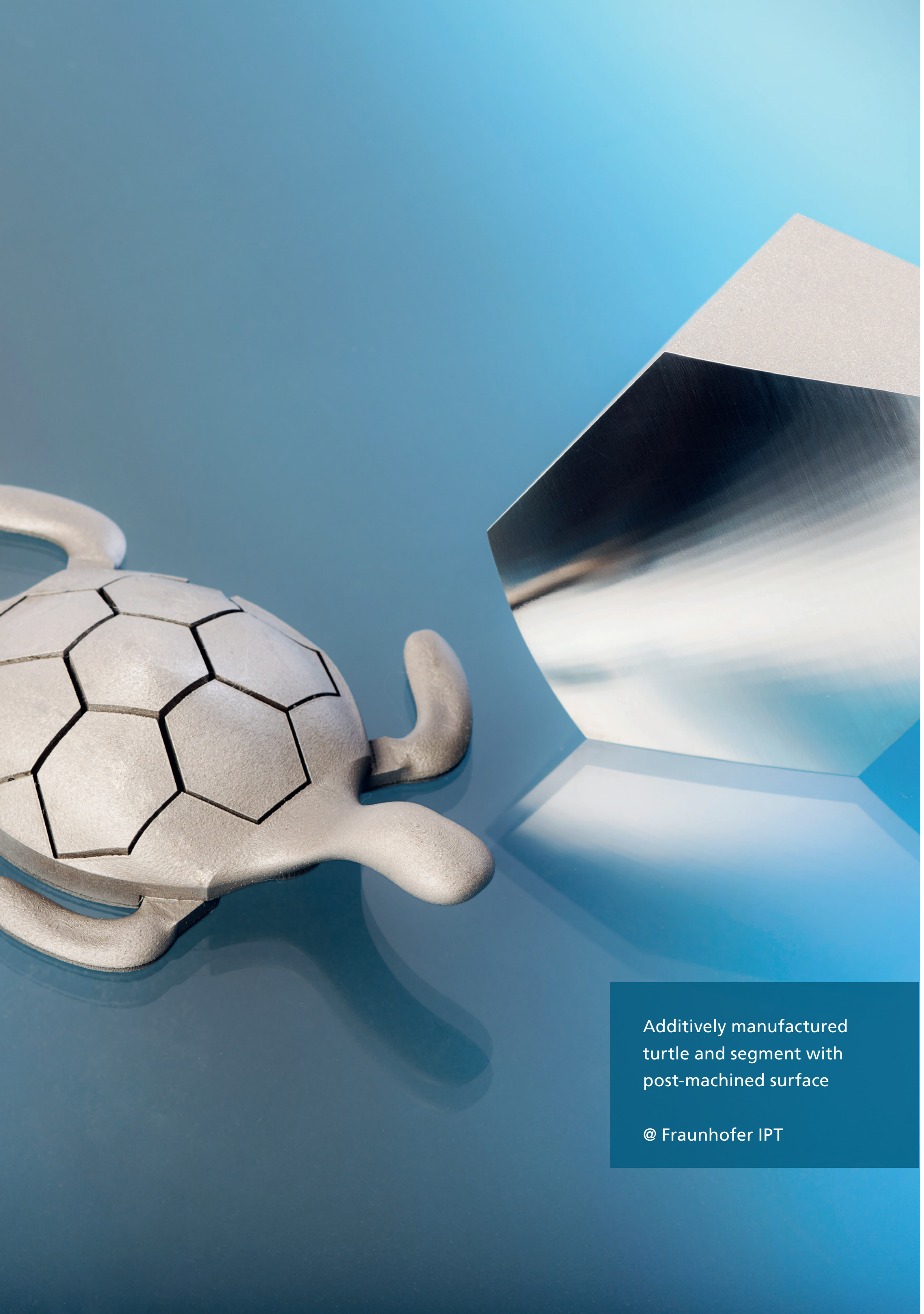

Additively manufactured turtle and segment with post-machined surface

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It‘s the final layer which generates values

Finishing and Refinement Solutions for Additive Manufacturing

Additive technologies offer possibilties that classic, subtractive machining processes do not, such as design freedom, lightweight construction or the efficient use of raw materials. However, the surface quality of additively manufactured components is typically insufficient or support structures have to be removed. Therefore, additive technologies usually only deliver semi-finished products. The final value is added through post-processing.

Depending on the material and the required function and quality, various technologies are available for finishing the component surface. The Fraunhofer Group for Production, an association of 13 institutes for research in production technology, presents nine examples of processes:

Conventional processes for smoothing surfaces are machining operations such as milling and sandblasting, but also vibratory finishing and stream finishing, which also belongs to vibratory finishing.

Plasma processes are used to clean and polish surfaces or to improve the wettability of metal surfaces with function-bearing coatings and for joining with polymers.

Laser structuring is used to introduce functional microstructures directly into the metal surface, for example for fluid transport or optical effects.

Selective coating and painting offer the possibility of providing components made of polymers with functional surfaces in a targeted manner.

A compact overview of the various technologies is provided by a joint exhibit whose individual parts were each processed using one of the technologies presented.

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Highly motivated employees up on cutting-edge research constitute the most important success factor for us as a research organization. At the Formnext 2023, they will showcase the technologies that will truly shape the future of 3D manufacturing.

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