Fraunhofer IAPT

Fraunhofer Research Institution for Additive Manufacturing Technologies IAPT

Annual Report 2024

From Hamburg Around the World and Beyond

Industrializing AM 4U

Contents

»For industry to respect planetary boundaries, it needs to be sustainable. It needs to develop circular processes that re-use, re-purpose and recycle natural resources, reduce waste and environmental impact.

Sustainability means reducing energy consumption and greenhouse emissions, […]. Technologies like AI and additive manufacturing can play a large role here, by optimising resource efficiency and minimising waste.[1]«

[1] European Commission, Directorate-General for Research and Innovation, Breque, M., De Nul, L., Petridis, A., Industry 5.0 : Towards a sustainable, human-centric and resilient European industry, page 14

We Secure our Industrial Future

With three major boosts, Fraunhofer IAPT has taken off in 2024 and laid the foundations for Hamburg's successful future as an industrial and high-tech location.

Together with stakeholders from industry, Hamburg politics and the Fraunhofer-Gesellschaft, we launched three significant projects for our economy and research last year: We began the construction of a new building to expand our research facilities, founded the IAMHH e.V. association and received approval for a Fraunhofer High-Performance Center of the same name.

Each of these steps contributes significantly to our mission of industrializing additive manufacturing for an internationally competitive industry and high-tech location in Hamburg.

The relevance of these major boosts for our metropolitan region extends far into our working lives and social interactions. On the following pages you can read about new career opportunities, how our daily research promotes energy transition and contributes to sustainable mobility — from Hamburg around the world and beyond.

You may even find links that address challenges you face. We look forward to discussing them with you and wish you an informative read.

Prof. Dr. Ingomar Kelbassa
and the Fraunhofer IAPT team

We aim to establish Germany as a pioneer in the areas of structural change in production technology 2.0, resilience and sustainability. Key technologies such as AM must be utilized in the future in a high-tech, production and high-wage country such as Germany.«

Prof. Dr. Ingomar Kelbassa,
Institute Director

May 2022: Initial talks with companies, research institutions and networks on an initiative to promote Additive Manufacturing (AM) to secure Hamburg's industrial future.

June 2022: Fraunhofer IAPT holds initial talks with Hamburg authorities on IAMHH.

November 2022: 20 Hamburg-based organizations from industry and research have expressed their interest in the IAMHH initiative in letters of intent.

January 2023: The number of declarations of intent increases to 40.

At the groundbreaking ceremony for the Fraunhofer IAPT (from left to right): Ulf von Krenski, Deputy Mayor of Bergedorf, Prof. Axel Müller-Groeling, Executive Board Member for Research Infrastructures and Digital Transformation of the Fraunhofer-Gesellschaft e. V., Second Mayor and Senator for Science Katharina Fegebank, Prof. Dr Ingomar Kelbassa, Director of the Fraunhofer IAPT, Prof. Dr. Andreas Timm-Giel, President of Hamburg University of Technology

Groundbreaking Ceremony for the Expansion of Fraunhofer IAPT

The federal government, the federal state of Hamburg and Fraunhofer-Gesellschaft are investing in the expansion of industry-related research and development for additive production technologies: Hamburg will be home to a new building for research into the industrial use of Additive Manufacturing at the Fraunhofer IAPT.

Infrastructure for industry-oriented research

The expansion of Fraunhofer IAPT promises companies and skilled workers in the Hamburg metropolitan region low-threshold access to the additive manufacturing route.

Covering around 1,100 square metres, the Fraunhofer IAPT extension will showcase the entire process chain with the latest plant and system technology. Users will be able to map their scenarios here with experts and specialists from Fraunhofer IAPT and realize cost and material savings as well as functional optimizations across the entire Additive Manufacturing route – from design to post-processing and finishing, including quality assurance. The floor space of the new building spans around 2,670 square metres spread over three floors. The areas of expertise and application as well as Fraunhofer IAPT's Additive Academy® will have work and training rooms.

May 2023: The »Industry Masterplan« of the Hamburg Senate, industry association, chamber of commerce and trade unions aims to make 3D printing usable for broad industrial applications.

August 2023: Outlines of initial project ideas for collaborative projects emerge. The IAMHH initiative has collected 60 declarations of intent from the Hamburg metropolitan region.

November/December: Fraunhofer IAPT specifies three pilot projects in the IAMHH initiative and organizes workshops on them.

»The Fraunhofer IAPT is an important bridge between science and industry. As a driver of innovation for next generation life science, energy, mobility and security, the IAPT is a central point of contact for companies in the Hamburg metropolitan region and far beyond. With the new building, we are strengthening the research and industrial production of sustainable products and resource-saving components. In this way, we are harnessing the potential of additive manufacturing and bringing it into wider use. For better environmental protection and prosperity in Hamburg, for more training and jobs and greater competitiveness on the global market.«

Katharina Fegebank
Second Mayor of the Free and Hanseatic City of Hamburg and Senator for Science, Research, Equality and Districts (BWFGB)

Visualization of the planned new building in Hamburg-Bergedorf

January to May 2024: Concept for a »Specialist for Additive Production« with HWK/Elbcampus as non-academic further training in the field of AM.

July 2024: Parallel to the constituent assembly of the IAMHH e.V., the Fraunhofer-Gesellschaft approves the Fraunhofer High-Performance Center IAMHH for the Fraunhofer IAPT.

October 2024: Groundbreaking ceremony – an extension to the Bergedorf Energy Campus will provide more space for Fraunhofer IAPT research.

IAMHH e.V. – Hamburg is Industrializing Additive Manufacturing

Additive production enables the digital manufacturing of the future and provides innovative answers to pressing social issues. Hamburg is prioritizing the development and use of this future technology with the »Industrialised Additive Manufacturing Hub Hamburg (IAMHH e.V.)« association.

From the Hamburg Industry Master Plan to IAMHH e.V.

Hamburg is Germany's largest industrial city. The Hamburg Industry Masterplan (2023) aims to strengthen and develop the local industry and attract new companies to Hamburg. The document identifies the use of new technologies, further digital transformation and the bidirectional transfer of science and industry as key areas for action.

In this context, Fraunhofer IAPT, the 3D Printing North Network, the Industrieverband Hamburg (IVH) and the Hamburg Chamber of Commerce have developed a vision of unbureaucratic public-private partnerships and vibrant networks of industry and science. These will systematically identify industrial demand for additive manufacturing, initiate demand-driven research projects and strengthen Hamburg's pioneering role in the field of Additive Manufacturing.

With the support of the Ministry of Economics and Innovation (BWI) and the Ministry of Science, Research, Equality and Districts (BWFGB), the initiative was successfully transformed into an association. Following the constituent assembly in July 2024, the association was officially entered in the register of associations as IAMHH e.V. November 1, 2024. The BWI is funding the activities of IAMHH e.V. in the Hamburg metropolitanregion via the Hamburgische Investitions- und Förderbank with around 840,000 euros until the end of 2027.

At the constituent meeting in July 2024, the 10 founding members signed the association's articles of association and unanimously elected the board of directors.

The board of the IAMHH e.V. association

- Ingomar Kelbassa (Fraunhofer-Gesellschaft)
- Mahendran Reddy (Fehrmann)
- Lennard Stoever (Zellerfeld)

November 2024: IAMHH e.V. is officially registered.

With the establishment of the association, Hamburg is sending a clear signal for the future of the industry. 3D printing combines innovation, sustainability and added value. Together with the companies and research institutions, we are driving the transformation to a digital and sustainable industry – and thus strengthening the competitiveness of our region.«

Dr. Melanie Leonhard
Senator for Economy and Innovation (BWI)

Read more here:

Page 16: AKROPOLYS, the first IAMHH e.V. pilot project that has already started, aims to create a local recycling economy for plastics.

Page 18: Zellerfeld designates a member of the board of the IAMHH e.V. The company relies on Fraunhofer IAPT and others to scale up its production.

From board to membership application – all information about IAMHH e.V. can be found here:

December 2024: On December 18, the inaugural meeting of the IAMHH association takes place at the Hamburg Chamber of Crafts.

Science, business and politics in Hamburg found the IAMHH e.V. association. At the same time, the Fraunhofer-Gesellschaft approves the Fraunhofer High-Performance Center IAMHH for Fraunhofer IAPT.

Fraunhofer High-Performance Center IAMHH

Due to the industrial relevance of additive manufacturing, the wide range of possible applications and, in particular, the broad local support for the IAMHH association, the Fraunhofer-Gesellschaft has granted Fraunhofer IAPT the status of a Fraunhofer High-Performance Center. In cooperation with the Fraunhofer High-Performance Center IAMHH, the IAMHH e.V. initiates and coordinates joint projects for pre-competitive development stages of new technologies.

The Fraunhofer High-Performance Center IAMHH focuses on the economic application of the results of the joint projects by transferring them to competitive development stages with the participating industrial partners – from prototype to proof of successful use of the new technology in the production environment at the industrial partner's site. Together with the new IAMHH e.V. association, the Hamburg University of Technology and Fraunhofer IAPT, the Fraunhofer High-Performance Center IAMHH offers a cross-organizational infrastructure for the industrialization of Additive Manufacturing in the Hamburg metropolitan region.

In January 2025, the Fraunhofer-Gesellschaft started supporting the transfer of innovations in additive manufacturing to industrial applications through the Fraunhofer High-Performance Center IAMHH, initially for three years with 1 million euros annually.

December 2024: The Fraunhofer-Gesellschaft approves the Fraunhofer High-Performance Center for the Fraunhofer IAPT.

The executive board of the Fraunhofer-Gesellschaft welcomes the IAMHH initiative as an important step towards strengthening the industrialization of additive manufacturing in the Hamburg metropolitan region. With our Fraunhofer High-Performance Center of the same name, we support this project and are convinced that it will make a significant contribution to securing northern Germany as a business location in the long term and to consolidating Germany as a leading high-tech production location.«

Prof. Dr. Axel Müller-Groeling
Executive Board Member for Research Infrastructures
and Digital Transformation of the Fraunhofer-Gesellschaft e. V.

January 2025: The management of the Fraunhofer High-Performance Center IAMHH at Fraunhofer IAPT starts its work.

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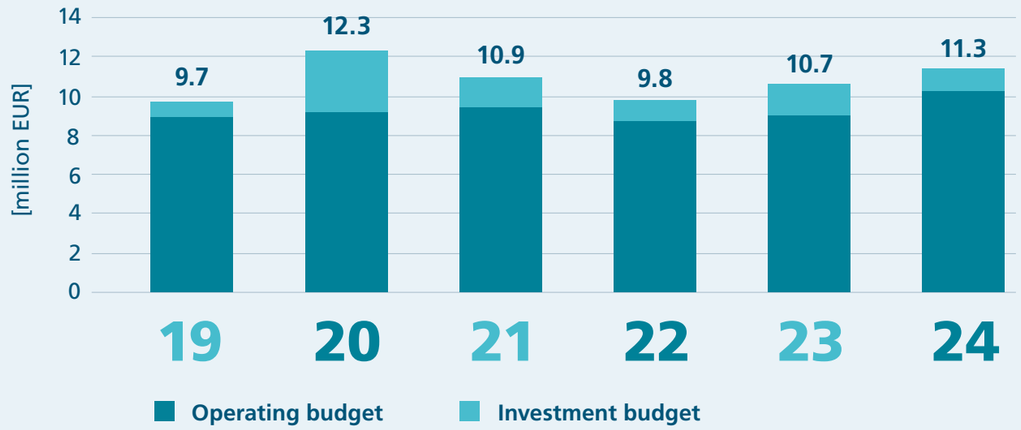
The Institute in Numbers

Overall budget



10.8 %
Business income

External revenue

1.1 Economic income

0.8 Contribution from Hamburg

4.2 German federal government

0.8 EU

0.1 Miscellaneous

As of April 4, 2025

Institutional funding

2.2 Basic funding

1.3 Special allowances

0.4 Internal Fraunhofer programs

0.3 Special circumstances

Expenses

7.6 Personnel

2.2 Non-personnel

0.7 Investments

Employees

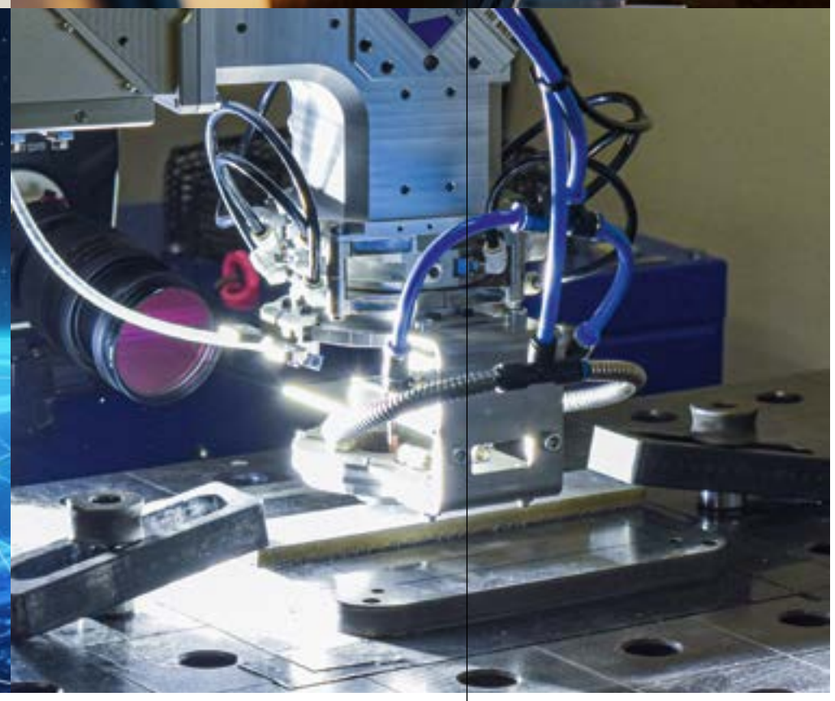
58 engineers and scientists

8 technical employees

18 internal services

45 students

2 apprentices



The Fraunhofer IAPT industrializes additive manufacturing and designs production environments for value creation with resilience and sustainability.

We Take Responsibility

Industrializing AM 4U

At Fraunhofer IAPT we optimize industrial production. We industrialize additive manufacturing and design production environments for value creation with resilience and sustainability. With expertise, creativity and courage, we develop answers to the pressing questions of the future.

As a supporter, leader and driver of the economy, we are committed to more than individual projects, working with partners from industry, academia and the public sector to realize innovation and transfer systems with impact. With projects such as the following, we are helping to secure Germany as a location for industry and high-tech.

Optimizing Components and Standardizing Production Processes

Additive manufacturing helps to increase innovation in space travel and improve the performance of satellites and spacecraft. Costs can also be reduced in the long term. The PBF-LB/M process also offers a number of advantages that make it particularly attractive for the aerospace industry:

- Increased performance through design freedom and functional integration
- Reduced effort for assembly and integration
- Shorter development and lead times
- Weight reduction

The successful implementation of additive technologies requires that the industry's high demands on quality and standards are taken into account throughout the entire manufacturing process.

AM Maturation project and procedure

As part of the AM Maturation project, OHB Systems AG and Fraunhofer IAPT have developed design, manufacturing and validation rules and processes for additively manufactured components. OHB is now using these rules and processes to utilize PBF-LB/M as a further manufacturing technology. The procedure has been validated by optimizing structural and optomechanical components for use on satellite platforms and in instruments.

Successfully achieved goals of the project:

- Development and optimization of a continuous and robust AM process chain, in particular with a focus on PBF-LB/M
- Development of design and verification expertise
- Development of a reliable supply chain for titanium and aluminium parts
- Successful completion of the new process chain for three components with increasing complexity

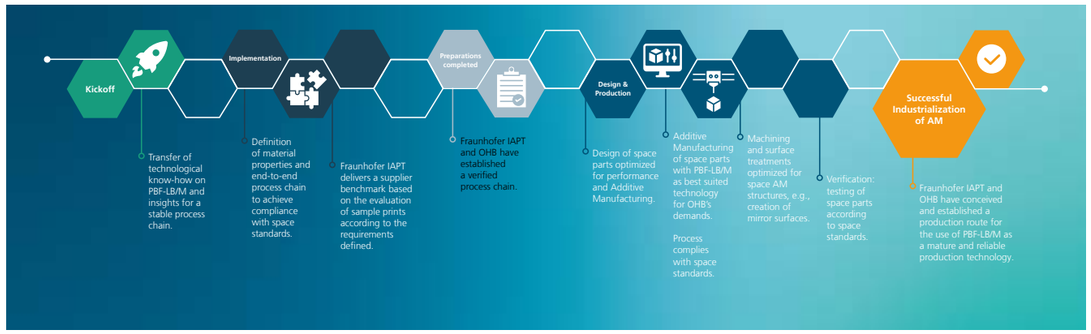


Figure 1: The process chain for the AM Maturation project

Fig. 1 shows the project procedure. Starting with a transfer of knowledge, requirements for aerospace were defined and the opportunities and challenges of a PBF-LB/M process chain were analysed. The process chain for manufacturing components using PBF-LB/M for aerospace was then defined. This included material analyses and supplier benchmarks.

After setting up the process chain, it was used to successfully design a total of three components. The selected sequence increases the complexity with each component. The ITM component therefore has the highest complexity in the selection:

1. Multi-directional stiffness bracket
2. Reaction wheel bracket
3. Integrated twin-mirror

The project team used the experience gained and the results of the individual runs to optimize and refine the process chain.

Components validate the process chain

Multi-Directional Stiffness Bracket (MDSB)

Material: Ti-6Al-4V

Several MDSBs are used in a satellite to connect two base plates made of different material combinations (e.g., aluminium and CFRP). Different thermal expansion coefficients of these base plates generate potential deformations, which are compensated for by the MDSB. A precise stiffness is required, which was optimized as part of the project.

Advantages of the developed MDSB:

- Defined stiffness properties due to controlled and optimized mass distribution
- Less deformation of the satellite structure and thus higher precision of the optical measuring systems
- Weight reduction of 45 percent

Reaction Wheel Bracket (RWB)

Material: Ti-6Al-4V

The reaction wheel bracket connects the reaction wheel to the satellite. The reaction wheels enable the rotation of the satellite. Typically, four reaction wheels and thus four reaction wheel brackets are used in a satellite. Reaction wheel brackets require a certain stiffness and should be easy to assemble.

Advantages of the developed reaction wheel bracket:

- Easy integration and assembly through directly embedded click nuts
- Reduced development time to adapt to changing boundary conditions
- Weight reduction of 20 percent
-

Integrated Twin-Mirror (ITM)

Material: Scalmalloy®

The integrated twin-mirror is an optical component in a spectrometer. Two surfaces of the component are machined as mirror surfaces. The high requirements involve specific stiffness and deformation properties. Thermal expansions must not affect the optical properties. For this purpose, the three mounting points were specifically optimized, which can only be produced through additive manufacturing (AM) due to this complex shape.

Advantages of the developed integrated twin-mirror:

- Reduced deformation of the mirror body due to optimized mounting points
- Improved optical properties due to higher thermal stability
- Weight reduction of 45 percent

With the help of Fraunhofer IAPT, OHB was able to establish a reliable process chain that now allows us to use high-quality AM components for our satellite projects.«

Dr. Marco Mulser
Head of Technology Coordination
OHB System AG

Our white paper on the project provides further insights and information on the components. Download it for free here:

The AM Maturation project illustrates the path from the requirements for products and manufacturing processes for aerospace to a customized end-to-end AM process. In addition to the manufacturing route, the project also includes elements such as supplier benchmarks and material tests.

The »Additive Manufacturing Maturation« project is being carried out as part of the ESA GSTP contract no. 4000125275/18/NL/AR/zk.

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Circular Economy with AM as a Contribution to the 2030 Agenda

Progressive climate change and the global sustainability goals of the United Nations 2030 Agenda are constantly leading to new legislation in Germany and the EU to regulate products manufactured and sold in the EU. Compliance with these laws requires, among other things, the establishment of a circular economy in the industrial production of plastics. In AKROPOLYS, a pilot project of the IAMHH e.V. association, Fraunhofer IAPT, together with industrial partners and members of IAMHH e.V., is meeting this challenge.

The AKROPOLYS project aims to develop a clear recycling concept for the reuse of materials in production and for products that have to be recycled at the end of their life cycle. Key requirements include the maintenance of material and product quality over several recycling stages. However, there is still a lack of reliable information on the recyclability of additively manufactured components. This is particularly true when considering the entire process chain from material production to the end of the product life cycle.

Developing a circular economy for additive production using polymers (plastics)

AKROPOLYS aims to establish a cross-product and cross-technology circular economy for AM processes using the material polyamide 12 (PA12). Materials and products will be 100 percent recycled wherever possible. The plan is to recycle used powder from the SLS process and reuse it in injection molding and material extrusion (FFF, FGF). The initial focus will be on highly functional lightweight products, production aids and consumer applications, as well as innovative designs in the art sector.

The joint project takes into account all product life cycles and relies on partners from different sectors in the Hamburg metropolitan region. These include three small and medium-sized enterprises and two research institutes. Hamburg-based Lehmann&Voss&Co KG is leading the project as consortium leader – and sixth partner.

In addition to the EU specifications, AKROPOLYS also considers industry requirements such as color, haptic and mechanical properties. These requirements are contributed by four associated partners in the pilot project, including two large industrial end users from the mobility sector. They specify products and product features in which the recycled materials are to be processed.

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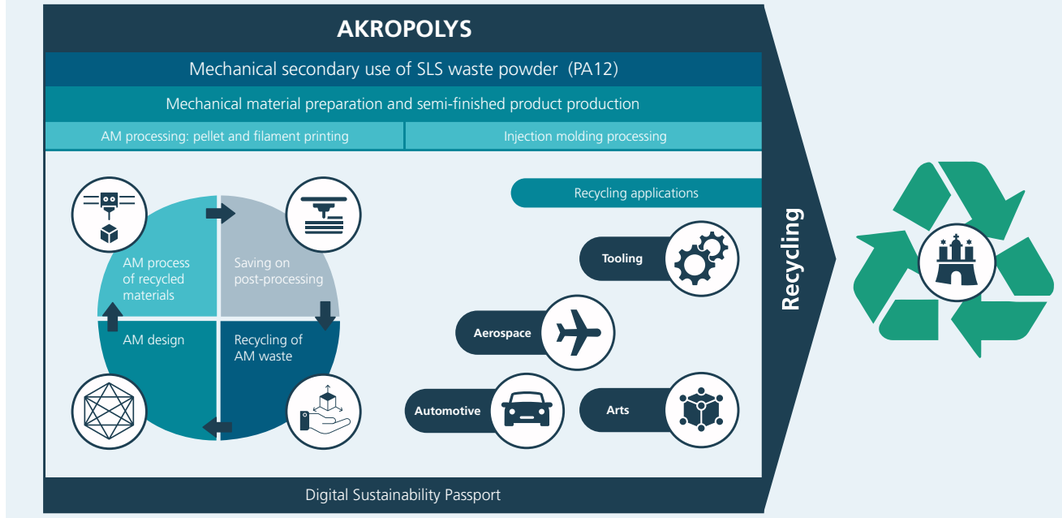

Life cycle within AM production

The AKROPOLYS joint project, with a total project sum of around 2.5 million euros, has received a funding commitment of approx. 1.75 million euros from the Hamburgische Investitions- und Förderbank (IFB) of BWI.

Contribution of the Fraunhofer IAPT to AKROPOLYS

- Testing the extrusion behavior and material properties of filaments prepared from SLS waste powders in the FFF process
- Development of a system based on laser diodes that can be directly integrated into the process for direction-independent smoothing of inner and outer surfaces
- Investigations into the flowability, mechanical and surface properties of FFF components made from recycled materials
- Development of a digital sustainability passport that enables digital identification of materials, documentation of the process history and CO_2 consumption as well as verifiable compliance with legal regulations
- Participation in design concepts with a focus on simple recycling: »Design for Circularity«

AKROPOLYS pools the expertise available in Hamburg in an ideal way to provide industry with sustainable materials for demanding applications.«

Dr. Stefan Schulze
Director 3D Printing Materials at Lehmann&Voss&Co. KG

Lennard Stoever from Zellerfeld (on the left) and Christian Böhm from Fraunhofer IAPT with shoes from Zellerfeld's production.

Christian Böhm

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Zellerfeld: How do you Scale up Additive Production?

Zellerfeld is a pioneer in the additive production of customized shoes based on individual scans. Production is completely digital and sustainable. Zellerfeld operates two hundred 3D printers for this purpose, but wants to scale this successful model to several thousand. Experts from the Fraunhofer IAPT are supporting the design of the new infrastructure.

Zellerfeld, a German-American company, is revolutionizing shoe production: Soles and upper materials from the 3D printer have already become established for sports shoes. But Zellerfeld goes further. The company has solved the challenge of additive production of a completely functional shoe with designs. The latest highlight in the company's history: Sports shoe manufacturer Nike is working with Zellerfeld and presented its first fully 3D-printed shoe in November 2024.

In view of its success, Zellerfeld would like to increase its production capacity. Upscaling from hundreds to thousands of 3D printers requires precise planning of spatial requirements and compliance with legal regulations and safety aspects. At the same time, Zellerfeld wants to identify and exploit the potential for optimization. To ensure the success of this major project, Zellerfeld brought in Fraunhofer IAPT and its expertise along the entire AM production route. The Fraunhofer institute's applied research contributes to the optimization of industrial production processes and supports Zellerfeld on its growth path.

Procedure and results

Fraunhofer IAPT and Zellerfeld completed the first phase of the project by defining the requirements for upscaled production in 2024. The first step was to review, validate and evaluate the key production figures of the current production concept that are relevant for scaling. The Fraunhofer IAPT team identified bottlenecks, highlighted potential for improvement and developed practical recommendations for action. Specifications, particularly for fire protection, have also been incorporated into the catalog of requirements and ensure safe and legally compliant production.

The central result of the Fraunhofer IAPT's work is a layout of the production environment. In addition to the arrangement of the production areas, it also takes into account office space and failsafe measures. A well-founded estimate of space requirements forms the basis for long-term improvements. Fraunhofer IAPT specified the technical and regulatory requirements for the selection of an optimal property as a future production facility. The concept enables Zellerfeld to implement its growth strategy in a structured and future-oriented manner and to significantly increase production from the current two hundred 3D printers to up to 5,000. It was developed in close collaboration with Zellerfeld's production staff. Personal interviews and on-site production support provided valuable insights into existing processes and challenges. The methodology ensures a solution that is sound in theory and geared towards the real needs of production in practice.

Fraunhofer IAPT helped us to validate key findings with a practical analysis – a valuable basis for our further scaling.«

Lennard Stoever
Co-Founder and President of Zellerfeld

Advantages of the Fraunhofer IAPT solution

- Independent advice and expertise
- Practical and innovative solution concepts
- Identification of optimization potential
- Definition of strategic recommendations for action
- Efficient expansion of production capacities
- Sustainable increase in competitiveness
- Early consideration of regulatory requirements
- Future-proofing for future scaling measures

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Supporting the Energy Transition With Additive Production

Hydrogen serves as a CO_2-neutral alternative to fossil fuels. In various projects, Fraunhofer IAPT and its partners are optimizing components for hydrogen production and distribution in the fields of energy technology and mobility. These include the H_2ERON and HyDroFit projects.

H_2ERON – shaping the energy transition economically

The overarching goal of the H_2ERON project is to develop a maximally productive and monitored process chain for powder bed-based laser beam melting. In order to significantly expand the field of application, the unit costs of additive production will be reduced to below 50 ct/cm³ and at the same time the CO^2 footprint of production will be reduced by 30 percent.

The consortium is pursuing two main approaches: Make the processes more efficient by increasing process capability and productivity and optimize the material and topology of the industrial demonstrator components in a targeted manner for additive production.

H_2ERON is funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK) via Project Management Jülich (PtJ) as part of the Lightweight Construction Technology Transfer Program (TTP LB).

Project partners:

- EOS GmbH
- Fraunhofer IAPT
- GKN Additive
- MAN Energy Solutions
- nebumind GmbH

HyDroFit: the dawn of climate-neutral aviation

The aim of the HyDroFit project is to perform tests with hydrogen-powered turbines in aviation. To this end, the project partners are creating a liquid hydrogen pipeline infrastructure that supplies sufficient mass flows and pressures for the operation of large-scale H2 consumers.

Fraunhofer IAPT is developing the process steps for manufacturing the required 3D-printed components in the field of hydrogen distribution. The focus is on a material composite of the additively manufactured components with CFRP components, which realize a fourfold weight reduction of the lightweight hybrid pipe components.

The HyDroFit project is funded by the Hamburgische Investitions- und Förderbank Hamburg (IFB).

Project partners:

- CompriseTec
- Deutsches Zentrum für Luft- und Raumfahrt e. V.
- Fraunhofer IAPT
- Hochschule für angewandte Wissenschaften Hamburg
- Lufthansa Technik AG

Expertise of Fraunhofer IAPT

In these and other projects, the experts at Fraunhofer IAPT develop and optimize the processes for manufacturing and joining additively manufactured components. Our teams also implement process monitoring systems and automated solutions for topology-optimized component designs.

Reducing CO_2 Emissions for Titanium Components

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

The Federal Ministry for Economic Affairs and Climate Action is funding the AMAvia, IKARUS and Greenhorn projects.

The project sponsor is the German Aerospace Centre (DLR e.V.).

The use of titanium as a raw material already contributes to the high CO_2 footprint of aviation during production. Conventional production methods also waste considerable quantities of the material through machining. In view of rising material costs, strict environmental requirements and increasing supply bottlenecks, the relevance of an optimised buy-to-fly ratio is increasing.

In three research projects, Fraunhofer IAPT is developing processes that significantly reduce resource and energy consumption in the production of titanium components. The experts at the Fraunhofer Research Institution for Directed Energy Deposition (DED) are researching and optimizing processes in combination with conventional production steps. The hybrid process chains generate significant savings in titanium and energy.

AMAvia

The project involves the further development of DED-Arc combined with laser-assisted DED-Arc for Ti-6Al-4V with machining processes to improve material properties and surface quality. A multi-robot production cell with the latest generation of control systems enables automated and flexible production.

The new pilot line at Fraunhofer IAPT enables DED production and subsequent post-processing in a single clamping operation. For large titanium structures in particular, this approach results in high cost and material savings.

Project partners:

- FOOKE
- Fraunhofer IAPT
- Heggemann
- racontec
- TU Hamburg
- Siemens

IKARUS

For thin-walled forged blanks that require localized reinforcement, Fraunhofer IAPT has tested the use of laser powder DED for Ti-6Al-4V. This enabled a 65 percent reduction in the amount of material required for the final component compared to conventional machining (target application: metal leading edge).

Fraunhofer IAPT has also optimized DED processes so that a local shielding method and a local gas nozzle replace the usual global shielding chamber. This means that the process requires less inert gas, especially for large components, and is more cost-efficient. Samples produced with the nozzle show an increase in elongation at break to 13 percent, which fulfils aviation-specific requirements.

Project partners:

- Access
- Fraunhofer IAPT
- Leistritz

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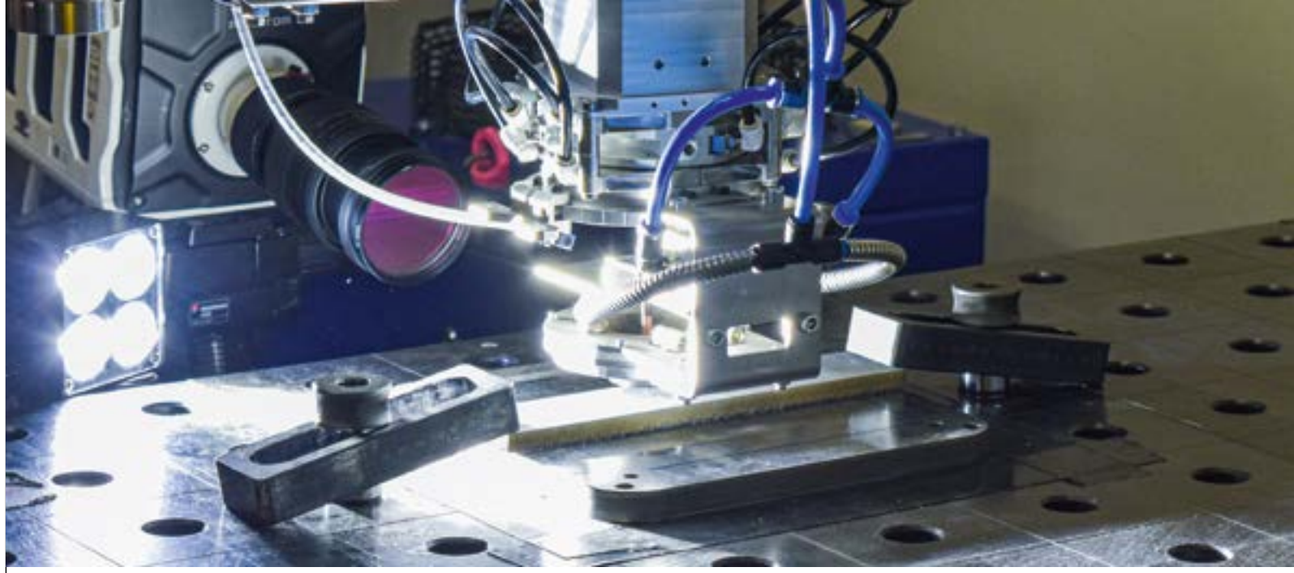
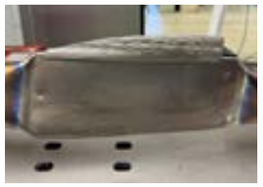




Greenhorn

Fraunhofer IAPT qualifies the DED-Arc process for beta titanium alloys in order to generate near-net-shape blanks for downstream molding processes. Compared to the machining of preforms, this results in material savings of at least 50 percent.

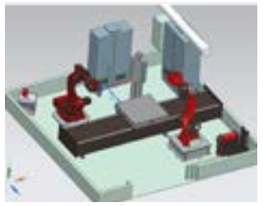
The integration of in-process monitoring solutions also provides important approaches for comprehensive data availability and quality assurance. Data is recorded and analyzed in a spatially resolved manner. Anomalies can thus be localized directly on the manufactured component and the effort required for subsequent inspection steps is reduced.

Project partners:

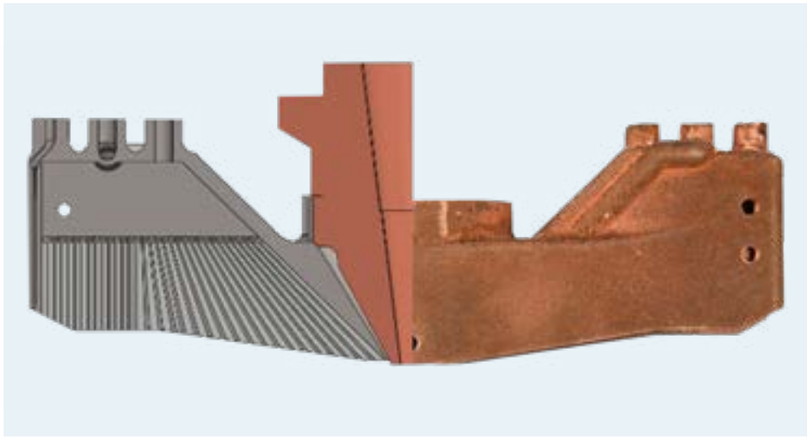
- BCT
- Fraunhofer IAPT
- Winkelmann

Reinforcement applied using DED (top), prototype of a reworked leading edge (bottom)

The direct transfer of findings from the projects is carried out by the aviation partners involved. These collaborations not only strengthen innovation in the industry, but also contribute to more sustainable production.



Robot-based machining (top) Hybrid production cell with DED-Arc (bottom)



Local shielding gas nozzle for laser powder DED process

Setting off Into the Crafts With the ELBCAMPUS

Additive manufacturing (AM) harbors enormous opportunities for the crafts – across all trades. With AM, companies can easily produce functionally optimized components themselves – whether innovative bicycle frames, pipe connections or cable holders. The same naturally also applies to spare parts or »spare parts on demand«.

A new ELBCAMPUS course organised by the Hamburg Chamber of Skilled Crafts offers non-academic access to additive manufacturing for skilled trades. The Fraunhofer IAPT supported the ELBCAMPUS with the concept and content design and provides participants with insights into the additive process chain and the technological infrastructure of the production route as part of the training program.

The new »Additive Production Specialist (HWK)« training program is aimed at experts in the non-academic sector: technicians with business acumen who can accompany SMEs into the arena of additive production.

These specialists must understand the devices down to the last detail, while also being able to develop ideas on how additive manufacturing routes can be used profitably in a company. Fraunhofer IAPT will be training such specialists together with the ELBCAMPUS in the future: The »specialists for additive production« will enrich both large companies and small craft businesses.

The »Additive Production Specialist« course comprises seven modules:

- Additive production basics
- Construction and design
- Procurement and commissioning of machines
- Source material management / materials science
- Machine operation and printer management
- Control and documentation (in-process)
- Component post-processing and finishing
- Quality assessment and packaging

ELBCAMPUS
Kompetenzzentrum Handwerkskammer Hamburg

In an interview in German with ELBCAMPUS, Prof Dr Ingomar Kelbassa, Director of the Fraunhofer Research Institution for Additive Production Technologies IAPT, answers questions about the training course: **3D printing as a driver of innovation: Additive production in the skilled trades – ELBCAMPUS**

Details, dates and booking

Access to the new eLearnings of the Additive Academy® is provided via the Fraunhofer learning platform ILIAS.

The Additive Academy® Repositions Itself

ADDITIVE ACADEMY

Fraunhofer IAPT is responding to the rapid development of additive production by reorganizing the Additive Academy®. Condensed learning paths address four fields of activity in research and industrial production. In addition to on-site training, the first learning paths are being launched as an eLearning format. The new Additive Academy® eLearning courses is accessed via the Fraunhofer learning platform ILIAS.

Focus on specialized roles

The new Additive Academy® program enables beginners to get off to a quick start and and provides a flexible way to bring experienced teams up to speed with the latest technology. The new learning paths reflect the division of tasks in companies. They provide researchers, product designers, production teams and managers with a targeted approach to the tasks they face on a daily basis. Participants can quickly apply the acquired knowledge in their day-to-day work and utilize the opportunities offered by additive manufacturing for innovation and competitive advantage.

eLearning on ILIAS

New eLearning sessions for the introductory courses supplement the program at the Fraunhofer IAPT on site. The Additive Academy® eLearning courses are accessed via the Fraunhofer learning platform ILIAS, where interested parties can get a first impression of the training program in an online demo.

Fraunhofer IAPT partners can also offer the eLearning courses.

Format for advanced AM teams

One highlight is the new »Design Consulting for Additive Production« course. Here, teams from one company or groups from several companies work on specific projects. Depending on the type and maturity level of the initial project, the course is organised as an open brainstorming session or as a session for the targeted solution of specific questions.

Click here for the online demo of the »Additive Production Basic Training«

Curators

Fraunhofer IAPT is delighted to have curators who have been with us for many years. We value the inspiration from industry, research and teaching. The valuable exchange at the board of trustees meeting helps us to stay on course and contribute to increasing productivity, resource conservation, resilience and prosperity with the industrialization of additive production.

We would like to thank our curator Dr. Karsten Heuser for his support of the IAMHH e.V. association – in its conception as well as the constituent assembly and at the founding event.

Siemens has been a mainstay in Hamburg for over 125 years and has played a central role in the digital transformation of the city. Whether automating container gantry cranes at the port, increasing building efficiency at Airbus or the digital suburban railway, numerous well-known companies rely on solutions from Siemens. As a founding member of IAMHH e.V., Siemens now also actively supports the development of a strong ecosystem for the industrialization of additive manufacturing in Hamburg. This technology is a decisive driver for many industries on the way to a resource-saving circular economy.«

Dr. Karsten Heuser
Vice President Additive Manufacturing, Siemens AG

Additive manufacturing is a technology of the future. With unprecedented design freedom, it makes the production of functional and complex components faster, more efficient and more resource-friendly. Additive manufacturing is an ideal fit for our strategic initiative »Engineering to Face Climate Change«. I am very pleased that the new building at IAPT also further strengthens the cooperation between Fraunhofer and TU Hamburg and that we can optimally serve the entire development chain from the basics to the industrial application of additive production technologies.«

Prof. Dr. Andreas Timm-Giel
President of Hamburg University of Technology

We would like to thank our trustee Prof Dr Andreas Timm-Giel, President of Hamburg University of Technology, for his participation in the groundbreaking ceremony for our extension building.

Other curators in this reporting period

Klaus von Lepel
Science, Research, Equality and Districts Authority (BWFGB), Head of Research Department / W2

Angela Titzrath
Hamburger Hafen und Logistik AG
Chair of the Executive Board

Stefanie Brickwede
Managing Director,
Mobility goes Additive e.V.

Dr. Tina Schlingmann
Regional Director EMEA: DACH & Benelux, EOS GmbH Electro Optical Systems

Dr. Klaus Kleine
Director Laser Application, Coherent Inc., USA

Christoph Hauck
Member of the Executive Board, toolcraft AG

Patent Grants

2024

»Formschlüssige Verbindungen unterschiedlicher Materialien und Verfahren zur Herstellung dieser mittels energiereichen Strahls im Pulverbett oder Polymerbad«

Interlocking connections of different materials and methods for their production using high-energy beams in a powder bed or polymer bath.

DE 102021117969
Inventors: Alexander Bauch, Maximilian Kluge

In addition, there were a total of three patent applications and three invention disclosures.

Research Partnerships

Fraunhofer partnerships

Fraunhofer Group for Production
Fraunhofer IAPT is a member of the Fraunhofer Group for Production (www.produktion.fraunhofer.de), a collaborative grouping of 11 Fraunhofer institutes and research units. Founded in 1988, the purpose of the group is to engage in joint research and development with a close relationship to production. By using the latest findings from production management, engineering and IT, the group offers a range of services that cover the entire product life cycle or value chain. It ensures that research and industry are closely networked, taking an interdisciplinary approach. The group provides German and international customers with comprehensive system solutions by combining the wide-ranging skills and experience offered by the individual members. In this way, they make companies fit for the production environments of the future. As a key member of the group, Fraunhofer IAPT provides it with expertise in the fields of industrial and autonomous solutions for additive manufacturing technologies.

Fraunhofer-Gesellschaft Competence Field Additive Manufacturing
The Fraunhofer Competence Field Additive Manufacturing (www.additiv.fraunhofer.de) integrates 19 institutes across Germany, meaning it reproduces the entire additive manufacturing process chain. This includes the development, application and implementation of additive manufacturing methods and processes. Its services are aimed at sectors such as handling and assembly, medical engineering, mobility, microsystems engineering and toolmaking, but can also be used across industries. Since it was founded in 2018, Fraunhofer IAPT has been a member of the Fraunhofer Competence Field Additive Manufacturing and contributes to joint contract research projects and trade show appearances.

Research partnerships

University Medical Center Hamburg-Eppendorf
The Life Science department at Fraunhofer IAPT works on various areas of research in conjunction with the Department of Oral and Maxillofacial Surgery (MKG) at the University Medical Center Hamburg-Eppendorf (UKE). The background to this partnership is the integration of additive manufacturing in the clinical workflow and its further development for specific applications.

The various focal points of the research are coordinated at the UKE by Prof. Ralf Smeets, who heads the Regenerative Orofacial Medicine division in the MKG. Prof. Smeets also works in an advisory capacity at Fraunhofer IAPT, with the aim of translating the ideas of medical practitioners into the language of engineers. The joint research activities range from digital image capture and processing to the application of AI for reconstructing medical anatomies, as well as the development of new additive processes and materials.

Helmut Schmidt University/University of the Federal Armed Forces Hamburg (HSU/UniBw H)
The Professorship Computer Science in Engineering at Helmut Schmidt University Hamburg (HSU) (www.hsu-hh.de) engages in a close strategic partnership with Fraunhofer IAPT. The department has more than 20 employees and is led by Institute Director Prof. Oliver Niggemann. It offers a broad range of expertise relating to methods of machine learning (ML) and artificial intelligence (AI) for cyber-physical production systems. The joint research activities combine the skills offered by the two research units and promote digitalization in additive manufacturing. Interdisciplinary projects support active knowledge transfer between employees at Fraunhofer IAPT and HSU.

The collaboration aims to increasingly explore joint projects in the context of HSU and other Hamburg partners in order to strengthen the local research landscape.

Networks

Additive Alliance®
The Additive Alliance® is the industrial research network for additive manufacturing at the Fraunhofer-Gesellschaft, with Fraunhofer IAPT acting as its organizer. Within the Additive Alliance®, Fraunhofer IAPT stages events and teaches companies about the opportunities presented by additive manufacturing. The concept combines talks and training sessions given by Fraunhofer IAPT along user reports and networking opportunities. Two events were held in both 2021 and 2022. In addition, researchers at Fraunhofer IAPT have conducted research into three of the challenges presented by Additive Manufacturing, which were chosen by the members. The resulting Deep Dives are available exclusively to members of the Additive Alliance® in the first year after publication. Mesago Messe Frankfurt, organizer of Formnext, has been the official sponsor and collaboration partner of the Additive Alliance® and of Fraunhofer IAPT since 2020.

3D-Druck Nord
3D-Druck Nord is the 3D printing network for the Hamburg Metropolitan Region and aims to promote the development of additive manufacturing in northern Germany. In 2018, the network was founded as 3DMRHH by the Hamburg Chamber of Commerce. Following a hiatus due to the pandemic, it returned in August 2021 with a new name and a new administration, but the same goal.

Fraunhofer IAPT works together with Hamburg-based partners Fehrmann Alloys, Deutsches Elektronen-Synchrotron (DESY), Hamburg Chamber of Commerce, Hamburg Chamber of Craft Trades and the Industry Association of Hamburg (IVH),along with the Lübeck Chamber of Industry and Commerce, Technikzentrum Lübeck (TZL) and Fraunhofer IMTE. Its goal is to network research and business in the AM sector in northern Germany, facilitate dialogue and increase the visibility of the Hamburg Metropolitan Region as a leading international hub of expertise in the field of additive manufacturing.

Mobility goes Additive
As a founding member, Fraunhofer IAPT has been actively involved in the Mobility goes Additive e.V. network for over five years. Originating from an initiative by Deutsche Bahn, the network aims to industrialize additive manufacturing, especially for the mobility sector. Fraunhofer IAPT leads the »Education« working group, probably the most significant international 3D printing network, and develops concepts for technology-related training and education. Additionally, Fraunhofer IAPT supports the approval of additively manufactured components for rail transport and the development of new materials, such as fire-resistant ones, in the »Approval« and »Materials« working groups. Since 2019, Fraunhofer IAPT has also been active in the newly formed sister network »Medical goes Additive,« striving to identify and implement innovative medical applications for 3D printing.

MN3D
Fraunhofer IAPT is a member of the steering committee in MN3D, the maritime network for 3D printing. Its members aim to unlock the potential of additive manufacturing in shipbuilding and other maritime applications, as well as initiate joint research and development projects in this area. The MN3D network operates in close collaboration with the Maritime Cluster Northern Germany (MCN).

Industry partnerships

3D Spark GmbH
3D Spark (www.3DSpark.de) was founded in June 2021 by three former employees of Fraunhofer IAPT. The company develops and markets software for identifying and quantifying cost savings in companies' production processes. To this end, it has analyzed CAD data, ERP data and technical drawings using AI-powered algorithms and identified the exact components that 3D printing can make more cost-effectively than methods that have been used previously. Fraunhofer IAPT and 3D Spark are collaborating in the field of software-based part screening in order to open up new applications for 3D printing and give customers the best possible advice when it comes to introducing 3D printing.

AMPOWER GmbH & Co. KG
For many years, Fraunhofer IAPT has maintained a close partnership with Hamburg-based consulting firm AMPOWER (https://am-power.de). As part of a joint training concept, the two combine their expertise in the field of binder jetting and offer a hands-on workshop that benefits customers by incorporating not only AMPOWER's comprehensive knowledge of the technology and market, but also Fraunhofer IAPT's expertise in processes and machinery. In addition, joint projects are undertaken to develop materials, including process design guidelines and qualification strategies.

Fraunhofer Industrial Application Center Quantum Computing Hamburg (Fraunhofer IQHH)
In 2023, Fraunhofer IAPT joined the Fraunhofer institutes ITMP, IAP and CML in founding the Fraunhofer Industrial Application Center Quantum Computing Hamburg (Fraunhofer IQHH) in the form of a virtual organization. The four partners are working together to develop resources and capacities in the new field of quantum technology.

Quantum computers can rapidly make calculations that conventional computers would take years to complete. Their capacity is redefining what it is possible to compute, and they are opening up huge opportunities for researchers and businesses to design and optimize products and production processes on the basis of innovative materials and logistics processes and systems. Fraunhofer IQHH represents a unique, applied source of skills and knowledge for the Hamburg economy.

Fraunhofer IQHH is also working with other networks, such as the Hamburg Quantum Innovation Capital (hqic) and the Fraunhofer Competence Network Quantum Computing. This allows the Application Center IQHH to access the extensive knowledge and expertise offered by the 12 Fraunhofer institutes in the Fraunhofer Competence Network Quantum Computing whenever necessary. As part of a national partnership with IBM, Fraunhofer has also obtained preferential access to IBM Quantum System One, which is currently the only quantum computer that can be used with secure IP access.

IAMHH e.V.
The IAMHH e.V. association was founded in November 2024 with ten members from politics, research, and industry, as well as three pilot projects. Fraunhofer IAPT is one of the founding members and its institute director, Prof. Dr. Ingomar Kelbassa, serves as the chairperson of the board of the association.

Organizations interested in membership can find more information on our **website.** Details about the founding of the association can be found in this annual report on pages 8 to 11.

Detecting defects before use in critical applications is crucial to ensuring the reliability of additively manufactured components.

The white paper analyzes four use cases on 29 pages.

Discovering Applications of Quantum Computing

Dr. Matthias Brück

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iapt.fraunhofer.de

Go directly to the email »

Quantum computing can solve complex industrial problems faster and more efficiently than conventional computers. The Fraunhofer Institute for Applied Polymer Research IAP, the Fraunhofer Institute for Translational Medicine and Pharmacology ITMP, the Fraunhofer Center for Maritime Logistics and Services CML and the Fraunhofer IAPT founded the Application Center IQHH in 2023 in order to communicate the potential and possibilities of quantum technology to industry at an early stage. You can find more information about Fraunhofer IQHH in this annual report on the pages about our collaborations.

The development of example applications is an important prerequisite for understanding and using quantum technology. IQHH has therefore developed four industrial applications of quantum computing, successfully implemented the corresponding quantum algorithms and ran them on simulators and real quantum computers. IQHH is now presenting the results in a 29-page white paper.

The white paper »Quantum Computing in Industrial Applications« provides insights into practical applications of quantum computing in various industrial sectors. It describes specific use cases and results. These help companies recognize the potential of quantum computing for their own challenges and to respond to this disruptive technology at an early stage.

Additive production and quantum computing

In the white paper, Fraunhofer IAPT presents a concrete industrial application example of quantum computing in the field of additive manufacturing.

Fraunhofer IAPT has investigated how hybrid Quantum classical convolutional neural networks (QCCNN) can be used to detect defects such as pore formation during the laser powder bed fusion (LPBF) process. The integration of in-situ sensor data and the use of quantum computing should improve quality control processes in additive production.

The white paper is aimed at companies from various industries, experts and decision-makers who are interested in the application of quantum computing in industry and would like to learn more about the opportunities and current developments.

Quantum Computing in Industrial Applications. Four Domains – Four Case Studies

Read now!

Scientific Publications

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Conference papers 2024

- BAUCH, A., HERZOG, D. (2024). Influence of temperature and beam size on weld track shape in laser powder bed fusion of pure copper using near-infrared laser system. J. Laser Appl. February 1, 2024; 36 (1): 012007. https://doi.org/10.2351/7.0001118.
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Doctoral Theses and Dissertations

Frank Beckmann

Laser Weldability of Laser-Additively Manufactured Aluminum Components
The weld connection of laser-additively manufactured (3D printed) aluminum components exhibits an unacceptably high weld seam porosity, which has not been previously investigated. This work provides an in-depth understanding of the laser weldability of these components and presents methods to optimize it. Initially, the causes of porosity are clarified. Based on this, optimized welding strategies for these components are presented, as well as measures to counteract the material-related causes of seam porosity already during the component creation process, the 3D printing process. Furthermore, design guidelines are developed that intuitively enable the designer to create assemblies in accordance with the process requirements.

ISBN: 978-3-662-69527-2
DOI: https://doi.org/10.1007/978-3-662-69528-9

Malte Buhr

Geometric Quality Sensor Technology for Robot-Based Additive Manufacturing
Quality assurance poses a significant challenge for the industrialization of additive manufacturing. Quality inspection is essential during the process. This work involves the development of an innovative laser triangulation sensor technology for geometric quality assurance in the robot-based directed energy deposition process. The influences on the sensors during in-process measurement are examined, and suitable measures for industrial application are derived. Based on this, the realization of a direction-independent sensor technology is achieved, along with its mathematical modeling and the calibration suitable for multi-camera multi-laser triangulation and the robotic system. The researched solution will serve as the basis for geometric quality assurance in additive manufacturing and for a better understanding of layer formation in the directed energy deposition process.

ISBN: 978-3-662-69316-2
DOI: https://doi.org/10.1007/978-3-662-69317-9

Philipp Kohlwes

Process-Stable Additive Manufacturing Through Spatter-Reduced Laser Beam Melting
The present research work is intended to provide information on how process stability as a criterion for quality assurance correlates with spatter intensity and which influencing variables affect it. In addition to the basic process parameters, the prevailing ambient pressure in the process chamber, the inert gas used, some properties of the powder material, and the effects of different laser beam shapes with regard to the resulting spatter quantity were investigated. Furthermore, an economic analysis was carried out, which deals both with potentials for increasing productivity, and with a cost consideration based on a case study in different scenarios.

ISBN: 978-3-662-69081-9
DOI: https://doi.org/10.1007/978-3-662-69082-6

Maximilian Vogt

Leveraging Potential through Augmented Reality in Additive Manufacturing
Due to demographic change, increased sustainability requirements, and the need to enhance the resilience of economic processes, the relevance of digital assistance systems in the workplace is steadily growing. In particular, the immersive technology augmented reality (AR) is assigned a significant supportive role as an interface between humans and machines in digital production.

This work comprehensively investigates the potential of augmented reality-supported digital assistance systems for use in industrial additive manufacturing and demonstrates it through a system development aimed at supporting manual activities in the process chain of the laser beam melting process, along with an economic evaluation. Given the interdisciplinary and application-oriented nature of this task, design science research was chosen as the framework, focusing on the purposeful and systematic use of methodological tools to develop human-centered systems. The developed system enables users without prior experience to perform complex setup and maintenance tasks on the production equipment and contributes to a significant reduction in errors compared to conventional knowledge transfer.

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Equality and gender
In certain cases, our wording does not use masculine and feminine forms of speech at the same time. This is to ensure better readability. However, this does not imply any discrimination towards the female gender; rather, it is intended to be a gender-neutral approach that aims to simplify the language.

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