01/2025 | EN

FonMag

READ AM I Application stories, interviews, news and insights about Additive Manufacturing

mesago

formnext

Messe Frankfurt Group

Never let a good crisis go to waste.

Winston Churchill, British Prime Minister, and author (1874–1965)

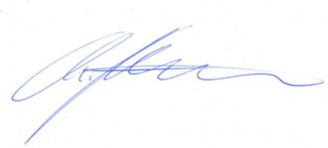
Ten years is an eternity in the fast-moving world of Additive Manufacturing. During this time, I have personally had the privilege of experiencing the rapid development of our industry from various perspectives – from the inception of Formnext right up to its 10-year anniversary celebration this year. What a journey!

The AM industry has undergone a remarkable transformation in this decade. We initially experienced a period of unparalleled growth, driven by technological breakthroughs; the AM market grew steadily and was expected to continue to record double-digit growth rates in the following years. Then came the coronavirus pandemic, which presented us with unprecedented challenges, but also demonstrated the flexibility and innovative power of our technology. Today, we are in a phase of consolidation and realignment. The market is maturing and we are seeing an increasing professionalization and industrialization of additive technologies.

This development is naturally accompanied by challenges. Competition is intensifying, cost pressure is increasing and it is becoming more difficult to raise money on the capital market. At the same time, exciting new opportunities are opening up, for example through new materials, applications or innovative business models.

I therefore look to the future with confidence. Additive Manufacturing has the potential to significantly advance the industry in many areas by supplementing and, in some cases, even replacing traditional manufacturing processes in numerous industrial sectors. We show you some examples in this issue, including those from the world of 3D Printing of ceramics (page 16) and the aerospace sector (page 12). At the same time, we look at the industry's efforts towards cross-company cooperation and industrialization (page 09).

After ten years, Formnext has also overcome many challenges and has grown up. Achievements that I, together with the entire Formnext team, am proud of. At the same time, I am sure that the next ten years will be no less exciting. I look forward to overcoming the impending challenges together with you and making the most of the opportunities that lie ahead. Let's continue to successfully shape the future of Additive Manufacturing together!

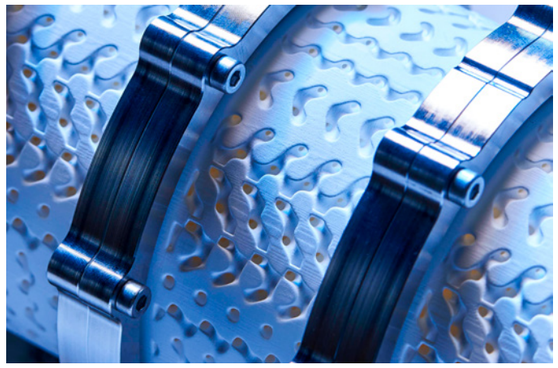


Sincerely, Christoph Stüker
Vice President Formnext

Cover: Thomas Masuch / For more information see page 15.

09

16

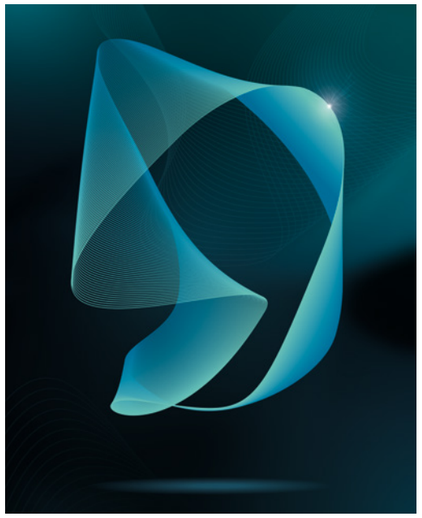


12

07

NEW KEY VISUAL

New year, new look! After the previous Formnext key visual has accompanied us for many years, it was time for a »refresh«. At the same time, we are ringing in our anniversary year with the »unveiling« of the new design. With its dark colours and elegant shapes, our new key visual immediately catches the eye. The further development of the previous design is characterised by simplicity and modernity, freshness and flexibility, making it an ideal symbol of the qualities of Additive Manufacturing. From now on, you will see our new key visual more often. And, of course, at the anniversary edition of Formnext 2025 in Frankfurt.



CRUCIAL MOMENTUM

With numerous groundbreaking world premieres and innovations, the exhibition provided crucial momentum for the future evolution of industrial production towards greater efficiency, productivity, and sustainability.

Despite a challenging economic environment and global uncertainties, Formnext 2024 has further confirmed its leading position. With 864 exhibitors (of whom 61% were international), Formnext set new standards once again. The event showed clearly how Additive Manufacturing is increasingly gaining in importance in a wide range of industries. The 34.404 experts and executives that Formnext welcomed as visitors this year are proof of this.

Formnext 2024 has significantly expanded its already extensive supporting program once again. Numerous showcases focused on user industries ranging from the dental and medical sectors to the packaging and construction industries and mechanical engineering. Key trends, technologies, and applications were discussed in the extended multistage program with three presentation stages that were freely accessible to visitors

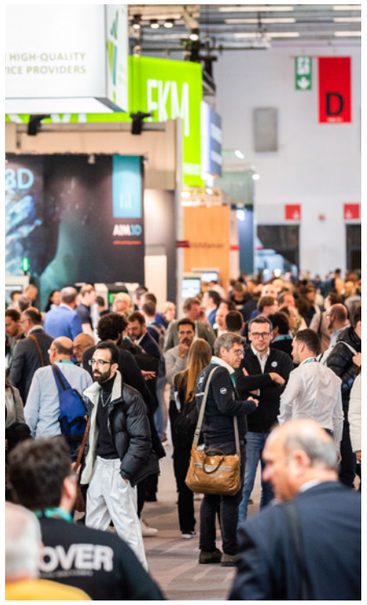


Image: Mesago / Matthias Kutt

Formnext 2024 once again attracted an exceptionally high proportion of international visitors (48%). Exhibitors also praised the impressive volume of visitor traffic and the high standard of discussions:

»As always, Formnext is the platform for showcasing innovation, collaboration and the power of the additive ecosystem,« says Shaun Wootton, Head of Communications, Colibrium Additive. Andreas Langfeld, President EMEA & APAC Stratasys, was delighted about »a super-strong trade fair and shared our knowledge on an even more sophisticated level. We also generated even more contacts and leads than last year.«

+ FURTHER INFORMATION:
» formnext.com/figures

INNOVATIONS RANGING FROM THE AORTIC VALVE TO MULTI-MATERIAL PRINTING

Winners of the Formnext Awards 2024 raising the bar in Additive Manufacturing

With its new awards format, Formnext is putting exceptional talents and ideas from the world of Additive Manufacturing in the spotlight. Following a jury evaluation and a public vote, these winners were recognized at the award ceremony on 21 November: Axolotl Biosciences (Start-up Award), Oryx Medicals (Rookie Award), Fraunhofer IGCV ((R)Evolution Award), Siemens / 3D-PROCESS research consortium (Design Award), Ceratizit (Sustainability Award), and AM of Bones, University of Stuttgart (AMbassador Award).

The Formnext Awards are presented across six different categories – including young innovative companies, sustainable business ideas, and pioneering technologies – to showcase the AM industry's ever-growing versatility. The trophies were designed by SUTOSUTO and produced by Voxeljet, which also sponsored the awards alongside 3D Printing Industry, AM Ventures, cirp, Renishaw, and Trumpf.

START-UP AWARD SUPPORTED BY AM VENTURES

The Start-up Award supported by AM Ventures, which is conferred on young, inspiring companies with viable business models, went to Axolotl Biosciences this year. This Canadian company has developed TissuePrint, a research-grade, xeno-free bioink for 3D Printing human tissue models. It claims that its ink can be used with an array of sensitive.

ROOKIE AWARD

Oryx Medicals took home this year's Rookie Award, which honors individuals with promising business ideas who have either not yet founded a company or who launched less than a year ago. The young team at Oryx Medicals has come up with a 3D printed aortic valve that is designed to revolutionize the treatment of aortic valve stenosis.

SUSTAINABILITY AWARD SUPPORTED BY RENISHAW

The Sustainability Award supported by Renishaw recognizes AM applications and products based not just on their production processes, but their entire life cycles. Taking home the prize this year was Ceratizit, a company that specializes in cutting tools and solutions for resistant materials, which has developed a unique procedure for additively manufacturing hard metals based on bonding agents and sintering. Ceratizit has calculated that this technique makes it possible to reduce the carbon footprint by 95 percent.

DESIGN AWARD SUPPORTED BY CIRP

Thanks to its exceptional AM designs, Siemens / 3D-Process research consortium was able to win over the jury and secure the Design Award in 2024. The German giant presented an innovative reactor design for greater sustainability in the chemical industry. According to Siemens, the system – which is designed to synthesize chemicals for active pharmaceutical ingredients (APIs) – consumes up to 50 percent less energy. It also requires around 50 percent less solvent than the conventional process.

(R)EVOLUTION AWARD SUPPORTED BY 3D PRINTING INDUSTRY

Coming in first in the running for this year's (R)Evolution Award supported by 3D Printing Industry was the Fraunhofer Institute for Casting, Composite, and Processing Technology (IGCV). This award is presented to pioneering products, technologies, or services that offer outstanding added value to the user.The IGCV convinced the jury with its project entitled »Three Material Powder Bed Fusion of Battery Cell Cap Housing«. It involves a three-material processing technology (patent pending) that uses powder bed fusion to manufacture battery cell housings from aluminum, copper, and ceramic in a single production step.

AMBASSADOR AWARD

The AMbassador Award recognizes outstanding individuals or organizations that have had a unique impact on the industry and users through innovative training and education approaches or personal advocacy. This year's winner: AM of Bones, University of Stuttgart. This university has developed innovative dental bone grafts together with dentists from the Freiburg University Hospital. The project involves the formulation of novel ceramic-filled resins and the design of highly accurate bone implants that are optimized for DLP stereolithography.

Image: Mesago / Marc Jacquemin

+ FURTHER INFORMATION:
» formnext.com/awards

INNOVATIONS AND PLENTY OF PRAGMATIC OPTIMISM

As the world's largest trade fair in the space, Formnext is a reflection of the entire AM industry. At Formnext 2024 the AM industry disclosed how manufacturers stand the test under increased pressure to operate economically and earn money. Besides, the industry proved to be pragmatic, optimistic, and – as always – extremely innovative.

Various AM applications at Formnext 2024 (clockwise from lower left): busts made of mineral powder from Concr3de; Carbon's Karen Korsmo presenting an athletic shoe; an urban model produced by IGO3D; and nozzles for a pressure cooker made by BLT

The mood on the trade fair floor was the opposite of pessimistic: clusters of visitors formed at many booths, with new technical innovations captivating more of them by the minute. Some AM systems even featured signs informing visitors about the sale of exhibits.

A POSITIVE MINDSET IN CHALLENGING TIMES

Nevertheless, it was also noticeable at Formnext that the AM sector is not immune to the challenging situation in many (user) industry sectors. However, the somewhat tougher (or simply changing) times were not necessarily seen as a negative omen. »It is becoming more difficult to expand, raise funds, and so on. But the struggle for survival makes people more creative,« reported Arno Held, managing partner at AM Ventures

Images: Thomas Masuch

THE IMPORTANCE OF USER INDUSTRIES IS SHIFTING

The automotive industry has been one of the strongest application sectors to date. However, at Formnext, a large number of corresponding exhibits showed that the aerospace industry, for example, has become an even stronger driving force for the AM industry (for more information, see the report from page 12).

BREADTH OF APPLICATIONS CONTINUES TO GROW

The AM world is also growing because it is expanding into more and more areas of application beyond medical and aerospace, such as electronics, energy, or the footwear and clothing sector. Areas of application that previously had a rather experimental character are now delivering real-world business stories. The same applies to the construction and architecture sector, where innovations for future applications were presented at the BeAM special showcase. Specific applications and business opportunities were shown by various exhibitors, such as 3D printed busts (Concrede) or animated models for urban and traffic planning (Team Kubitur at the IGO3D booth).

STRONGER COMPETITION FROM THE FAR EAST

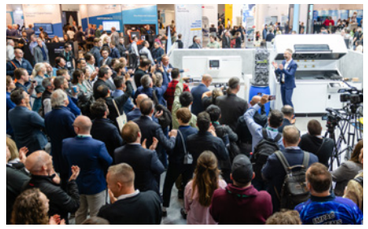
Companies such as BLT demonstrated the new self-confident »Chinese mindset«: The Chinese manufacturer of AM equipment exhibited real solutions for mass production in AM, including a nozzle for a pressure cooker that BLT claims costs just U.S.$1.60 to 3D-print (instead of U.S.$2.50 in the traditional MiM process). »We produce 1.5 million of these per year,« reported a proud Gary Ding, managing director of BLT Europe GmbH.

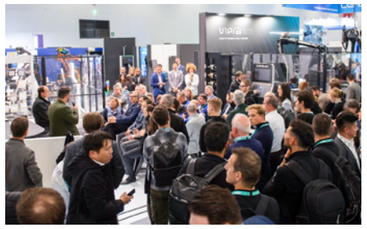
+ FURTHER INFORMATION:
» formnext.com/fonmag

FORMNEXT LAUNCHES – HIGHER PRODUCTIVITY, LOWER COSTS

The demand for lower production costs is as old as Additive Manufacturing itself, and of course Formnext 2024 was also about producing 3D printed components more cost-effectively. Progress was made in all exhibition halls and along the entire process chain, ranging from improved exposure strategies and innovations in materials and post-processing to improved software solutions that accelerate the design process or reduce waste. The highlights once again included the presentations of new hardware systems. The large number of visitors in attendance showed just how great the industry's interest in greater efficiency is. There was a packed floor at the launch of the EOS PE Next, for example. With this new SLS 3D printer, EOS promises up to 50 percent higher productivity, exceptional part quality, and support for biocompatible materials. The Stratasys booth was no less busy with the presentation of the new PowderEase T1 system, which the company launched together with the Rösler brand AM Solutions – 3D Post Processing Technology. Designed for the Stratasys H350 SAF powder bed printer, the three-in-one post-processing solution is said to save 50 minutes per print while reducing powder waste. The PowderEase T1 is manufactured at AM Solutions' German site. Caracol picked up on the important trade fair trend in the large-format Additive Manufacturing (LFAM) of metals with its new Vipra AM system, which the company presented with some fanfare and an accompanying panel discussion. The system uses wire-arc Additive Manufacturing (WAAM) technology and, according to Caracol, is suitable for large-format applications in the railroad, automotive, shipbuilding, aircraft construction, and furniture manufacturing sectors. It also combines robot-assisted AM technology with automation.

From left: product presentations at Formnext 2024 from Stratasys, EOS, and Caracol





Images: Mesago/Marc Jacquemin/Mathias Kutt

CONFIDENCE DESPITE A TENSE SITUATION

The member companies of the VDMA's Additive Manufacturing Working Group (AG AM) are confident about the future despite the tense economic situation: in its fall survey, 65% expected growth in the domestic market over the next 24 months. »Our member companies are demonstrating remarkable stability in what is currently an extremely difficult market environment,« explains Dr. Markus Heering, Managing Director of AG AM. Although 35% of companies are reporting declining sales, optimism remains at a high level. 58% of AG AM's member companies anticipate an increase in exports, although this does correspond to a decline of 10 percentage points compared to the spring survey. Almost three quarters of the member companies cited the EU as their most important export region, followed by the USA (69%) and European countries outside of the EU (33%). »We are watching the USA gain importance as an export market,« Heering continues. Meanwhile, China and other Asian countries were specified as the most important sales markets by 10% and 15% of the companies, respectively. The most relevant competitors come from China and the USA, with 43% of the respondents seeing themselves in competition with Chinese AM providers and 36% with their US counterparts. »The competition from China is now clearly noticeable,« Heering reports. In view of the difficult general economic situation, companies are currently holding back on investments. In 2025, only 27% intend to increase their outlay in this area. The most positive effects on the AM business will come from new applications (68%) and new markets (52%). One in five companies also hopes that increased R&D and marketing activities will have a positive impact. Heering sees lower costs, the development of new applications, and the development of new technologies that focus primarily on series production as important challenges for the future. »Automation will play a decisive role here,« he predicts.

HOW TO MASTER THE BIG CHALLENGES

The industrialization of Additive Manufacturing is one of the most important topics for the future of the industry, but there are still many hurdles to overcome.

Text: James Woodcock

The industrialization of AM refers to the transition of Additive Manufacturing from a niche prototyping tool to a fully integrated production technology capable of meeting the demands of large-scale manufacturing. It's about making AM a viable production technology, integrating it into traditional manufacturing operations at scale.

In the end, manufacturing decisions revolve around cost reduction and profit maximization. AM must deliver economic value to gain widespread adoption. However, due to geopolitical instability and supply chain challenges, AM doesn't necessarily have to be perfect to make an impact — it just has to be good enough to address pressing manufacturing problems effectively.

WHY HAS AM NOT ALREADY ACHIEVED FULL INDUSTRIALIZATION?

The industry has been discussing AM's industrialization for years, yet significant challenges remain, as the following:

- Materials
- Process stability
- Automation
- Standardization
- Efficiency
- Design
- Workforce development
- Trust and confidence

Two key groups drive industrialization: those using AM and those developing AM technologies. Users play a crucial role by finding ways to integrate AM into their production workflows, identifying real-world challenges, and refining applications to improve efficiency. Meanwhile, technology developers work on advancing hardware, software, and material capabilities to enhance AM's reliability, scalability, and cost-effectiveness. Both groups must collaborate closely to ensure that AM meets the evolving demands of industrial production. While users can only deploy what the industry provides, they play a critical role in refining applications and addressing real-world challenges. »

Images: EOS, Siemens

This heat exchanger produced by EOS and nTop exemplifies the key benefits of AM that are driving the industrialization of the technologies: part consolidations, novel alloy use, complex geometries.

The founders of AM I Navigator: **François Minec** (Global Head, Polymers 3D Printing, HP 3D Printing), **Martin Back** (Managing Director, BASF Forward AM), **Karsten Heuser** (Vice President Additive Manufacturing, Siemens Digital Industries), **Felix Ewald** (CEO & Co-Founder, DyeMansion) & **Nikolai Zaepernick** (CBO, Managing Director, EOS)

CHALLENGES REMAIN

Despite its potential, several barriers prevent AM from achieving full industrial adoption:

- **Cost:** At large volumes the cost of AM is often prohibitive in a like-for-like comparison with manufacturing technologies with decades of refinement behind them (and try as we might, people will continue to make like-for-like comparisons).
- **Process consistency & QA:** Consistency challenges are commensurate with the complexity of the process, and AM has a ton of inherent complexity across everything from materials to finishing.
- **Interoperability and integration:** Successful adoption requires seamless integration into existing production lines, often consisting of mixed manufacturing technologies. Many manufacturers struggle with software interoperability, data handling, and workflow automation.
- **Material limitations:** While the range and properties of materials for AM have advanced, they remain limited compared to traditional options.

COLLABORATION (AGAIN!)

Collaboration across the AM ecosystem is essential to overcoming these challenges. Several initiatives are actively addressing these barriers and pushing AM toward industrialization:

- **AM I Navigator:** Launched at Formnext 2023 by Siemens, DyeMansion, BASF Forward AM, EOS, and HP, and now including Stratasys, AM I Navigator provides a structured roadmap for AM integration. It offers a Maturity Model outlining five stages of AM adoption: Basic, Professional, Advanced, Integrated, and Autonomous. This allows companies to assess their progress and receive tailored recommendations on automation, connectivity, and operational optimization. Similar to Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs) in the defense industry, this framework helps manufacturers scale AM more effectively. »The AM I Navigator provides a structured approach to defining the current status and the steps toward the target state of industrialized Additive Manufacturing. It builds on established frameworks for digital manufacturing, such as the Smart Industry Readiness Index (SIRI), which helps companies to develop strategies for the modernization of their production processes,« says Dr. Karsten Heuser, VP Additive Manufacturing; Head of Company Core Technology AM & Materials, Siemens AG:
- **Leading Minds Consortium:** Announced at Formnext 2024, the Leading Minds Consortium – comprising Ansys, EOS, HP, Materialise, Nikon SLM, Renishaw, Stratasys, and TRUMPF –aims to address fundamental barriers to AM adoption. By aligning manufacturers and technology providers, Leading Minds aims to make AM more standardized, accessible, and scalable.
- **World Economic Forum's AM Initiative:** The World Economic Forum (WEF), in collaboration with Fraunhofer and ETH Zurich, has also taken a leadership role in AM industrialization. Their white paper, An Additive Manufacturing Breakthrough: A How-to Guide for Scaling and Overcoming Key Challenges, offers a structured approach for scaling AM. This initiative focuses on process standardization, workforce development, and investment strategies.

THE PATH AHEAD

In an increasingly unstable world, supply chain resilience is a pressing concern. Here, AM doesn't need to be flawless – it just needs to be a viable alternative that addresses these pain points. Identifying these use cases requires time and a deep understanding of real-world manufacturing challenges.

Another factor shaping AM's role in industrial production is sustainability. Environmental concerns once seemed to be at the forefront of manufacturers' minds, but weak regulation and shifting political priorities have changed those dynamics. However, commercial sustainability remains a constant driver.

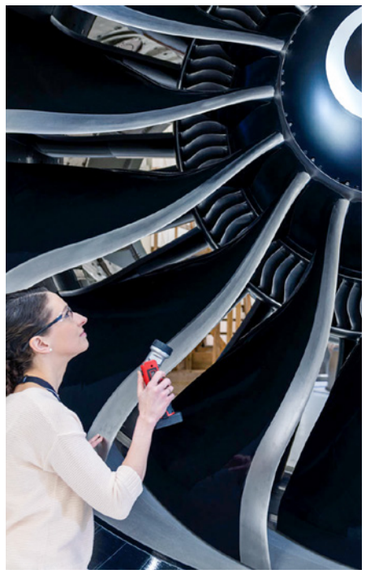
Ultimately, industrialization requires AM to move beyond the technology itself and embed itself into the broader manufacturing mindset. This means focusing on cost reduction, improving process stability, and ensuring seamless integration with existing manufacturing systems. Only by addressing cost, consistency, and integration challenges can AM fulfill its promise as a truly transformative industrial technology.

+ FURTHER INFORMATION:
» formnext.com/fonmag

ENGINES, ANTENNAS AND LUXURY VASES

A growing number of additive applications are driving the aerospace industry forward. The sector also offers great potential for further development.

Text: Thomas Masuch



Additive Manufacturing has been used in the aerospace industry for more than 30 years, and today all major aircraft and engine manufacturers have integrated the technology into their production processes. The GE9X turbofan engine from GE Aerospace shows how far this process has already progressed: The largest and – with a maximum thrust of 597 kN – most powerful engine in civil aviation contains around 300 additively manufactured components.

Additive Manufacturing is also playing an increasingly important role in the construction of satellites and rockets in the aerospace sector: More and more companies, including many start-ups, want to get involved in the zero-gravity business and are using 3D printed components and engines for their rockets. Or they just print an entire rocket, like Relativity Space.

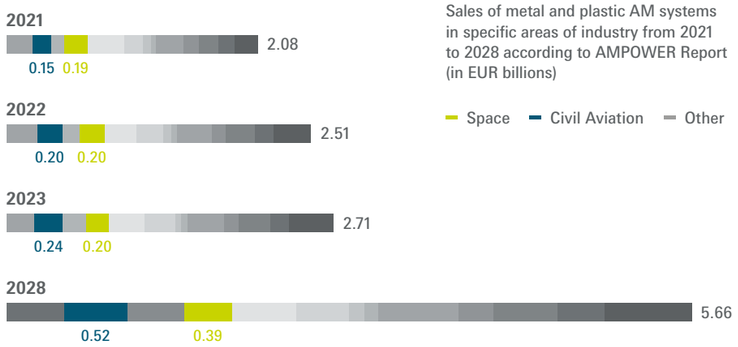
The space market is currently dominated by SpaceX: According to Brycetech, Elon Musk's US company transported 518 satellites into space in the third quarter of 2024 alone – around ten times as many as China's CASC, the world's second most important space company. The European Arianespace only managed to launch 12 satellites. SpaceX also uses Additive Manufacturing for its Raptor engines and has recently used DfAM to further optimize the design of its engines. Compared to the Raptor 1, the weight of the Raptor 3 has been significantly reduced from 2080 kg to 1525 kg, while the thrust has been increased from 1700 kN to 2750 kN, according to the company.

IMPORTANT USER INDUSTRY

The importance of aerospace for Additive Manufacturing (and vice versa) was particularly evident at Formnext 2024. Corresponding applications were on display on numerous stands of machine manufacturers, service providers and other companies, ranging from large rocket engines, which were either completely printed (AMCM) or had numerous additively manufactured components (Trumpf), to smaller thrusters for satellites (e.g. EOS, service provider FKM and many others), antennas, plastic components for aircraft interiors and numerous metal components for aviation.

Space and aviation are now often regarded as separate user industries. And that makes perfect sense, because the requirements and strategies of a start-up that wants to launch rockets with 3D printed engines into space are very different from those of an aviation company such as Airbus or Boeing.

One of the reasons why Additive Manufacturing is so successful in both industries is that in most cases only small quantities are required. AM can also demonstrate its full capabilities in complex designs. This is another reason why the aviation and space sectors are among the most important user industries for Additive Manufacturing. According to the Wohlers Report, AM in the aerospace sector generated sales of USD 1.01 billion in 2023, which corresponds to 13.3% of the AM market. The proportion is even higher if you only look at the machines sold: According to the Ampower Report, machines worth EUR 440 million were sold to companies in the »Space« and »Civil aviation, turbines, helicopters« sectors in 2023, which corresponds to a combined share of 16.3% (Ampower has calculated sales of AM equipment to be worth EUR 2.71 billion in 2023) According to Ampower, turnover in both areas is set to roughly double by 2028.



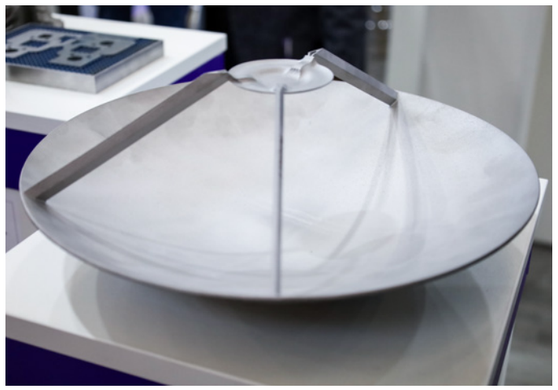
Sales of metal and plastic AM systems in specific areas of industry from 2021 to 2028 according to AMPOWER Report (in EUR billions)

APPLICATIONS IN THE SPACE INDUSTRY

A wealth of exhibits at Formnext 2024 showed that the space sector is constantly discovering new applications in addition to the already lucrative printing of engines and components for satellites. Among other things, Addup exhibited a very light antenna for satellites, while CONCR3DE presented a precise lightweight ceramic structure that can be used in telescopes, for example. In any case, space was also an important topic for other suppliers of ceramic 3D Printing, as this material is very well suited to the harsh conditions in space due to its inert properties (see article on page 16).

Dubai-based company Leap71, which specializes in AI-based engineering technology and develops rocket engines, »

Opposite page:
The new Raptor 3 engine from SpaceX and a GE9X turbine from GE Aerospace
At right:
A flight-ready Cassegrain antenna that Thales Alenia Space developed with Addup. 325 mm in diameter and 1 mm thick, it weighs just 385 g.



Images: SpaceX, GE Aerospace, Thomas Masuch

among other things, shows just how quickly development is progressing. The company recently presented a 1.30 meter high 3D printed 200 kN rocket engine. The component, which was manufactured on an Eplus system in 354 hours, is said to be the world's largest rocket engine printed in one piece. In December, Leap71 then announced that it had additively manufactured and tested an aerospike engine made of pure copper that generates a thrust of 5 kN and was developed in just a few weeks.

The new RL10E-1 copper engine, which the US company L3Harris delivered to its customer United Launch Alliance (ULA) in November 2024, is significantly larger. The RL10 engine has been in use for more than 60 years and has launched hundreds of satellites into space. Thanks to Additive Manufacturing, L3Harris was able to reduce its number of components by 98 percent. With a thrust of around 210 kN, the new engine is set to propel a Vulcan rocket into space this year.

Applications in aviation

There is an enormous range of applications in the field of aircraft construction and aviation – this also became clear at Formnext 2024: Metal components of turbines, structural elements, distributors and much more were exhibited on numerous stands. EOS presented a range of components for various AM users in the aerospace sector, including a miniature jet engine printed in 118 hours from nickel alloy IN718 with support-free overhangs of less than 35 degrees. Plastic applications were no less numerous and ranged from decorative vases for business class cabins to air ducts and caps for armrests.

3D printed drones and their housings were also clearly in evidence at Formnext 2024, although this is certainly a specialized sector of aviation which has requirements that differ completely from the construction of airplanes. Drones are all about efficient production – intelligent designs, for example, ensure that numerous drone bodies can be stacked on top of each other and printed in one construction job.

At the same time, new technological developments and materials are also opening up new business opportunities. The AM Craft start-up, which presented its interior solutions at the Stratasys stand, specializes in procuring spare parts for aircraft. If, for example, interior components on individual seats are damaged, the seats may have to remain unoccupied. And sometimes airlines have to reorder entire sets even though they only need one component. This is not only expensive but also time-consuming. At Formnext, Stratasys presented a solution that allows airlines to print the components they need themselves or purchase them from certified service providers. Stratasys supplies the machine and the material and helps with the certification of the process.

Above:
Rocket engines that are either partially or entirely 3D-printed were a leading topic at Formnext 2024. Pictured here: engines from AMCM (above) and Trumpf
At right:
A 3D-printed aircraft interior from AM Craft

Images: Mesago/Marc Jacquemin (2), Thomas Masuch (3), L3Harris

At left:
A manifold made of Ti6Al4V that was developed by Airbus and manufactured on an M2 Series 5 machine from Colibrium Additive
At right:
An RL 10 engine from L3 Harris

CHINESE MANUFACTURERS CROWD THE MARKET

Chinese AM manufacturers are making great efforts to position themselves as system suppliers or development partners for important users and suppliers in the aerospace industry. For example, BLT proudly presented an O-ring seal that was printed on a BLT-S400 and is used in the Airbus A330.

Western industry insiders reveal in confidential discussions that some Chinese manufacturers are so committed to entering the market that components are offered at prices below the cost of materials or that the manufacturers themselves bear the entire costs of development.

CHALLENGES AND OUTLOOK

One of several indications that the aerospace sector offers excellent business opportunities is the fact that Sintavia, one of the major AM contract manufacturers, invested a further USD 25 million in its already extensive and modern production facility in Florida in 2024.

However, the fact that not all of the potential in the industry is being exploited is also due to the bottleneck of post-processing. Although there is sufficient plant capacity at Airbus and its suppliers, post-processing is prescribed and regulated for quality assurance purposes.

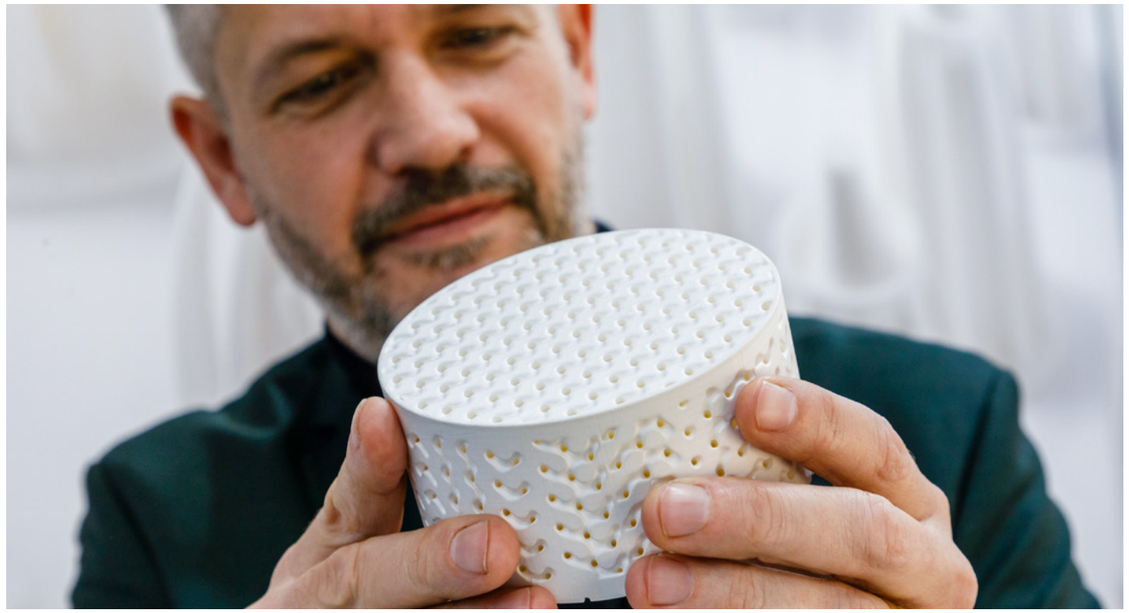
»It takes a lot of time and special processes, some of which are only available externally, to process printed parts ready for installation. The processes include heat treatment, non-destructive testing and surface finishing. Usually these are specifically required only for additive components, which makes it less attractive to offer this expertise. This is why there are only a few suppliers for the industry, some of whom have hardly any aviation experience,« explains Jan Roman Hönnige, who is responsible for Manufacturing Engineering DED at Airbus.

EASA sets very high requirements for certification, which can make it difficult for smaller AM or testing service providers to comply with the internal requirements and those of the authorities.

The demands that a company like Airbus makes on the further development of Additive Manufacturing are also based more on practical considerations: »To increase the footprint, we don't need any specialization of the technologies, any special solutions for individual components or any development of special new materials,« says Hönnige. »We need a harmonized supply chain that understands our challenges and certification processes, otherwise we are solving problems that are not at the top of our list. This calls for strategic decisions and better communication.«

+ FURTHER INFORMATION:
» formnext.com/fonmag

»A FOOT IN THE DOOR OF MANY APPLICATIONS AND INDUSTRIES«



The 3D Printing of ceramics has enormous potential in numerous industries. However, the complex technology is not easy to master. An overview of the status quo.

In his job, Norbert Gall has adopted a modesty that is quite unusual for his position: As head of marketing at Lithoz, a specialist in the 3D Printing of ceramics, he encounters new, highly innovative development projects and applications practically every week. But he can only use a few of them for his work. »Unfortunately, we are not allowed to show most of them, as we have usually signed NDAs,« Gall explains. Indeed, he and his team are delighted when he is allowed to bring one in perhaps 20 applications into the public eye.

One such application was ceramic filter membranes for lithium production, which the company presented to international experts for the first time at Formnext 2024. The British company Evove, which specializes in filtration technology, produces the membranes on a CeraFab S320 from Lithoz and stacks them into modules one meter in length. Thanks to improved designs, Evove expects the ceramic membranes to deliver higher performance and a longer service life for the filter elements.

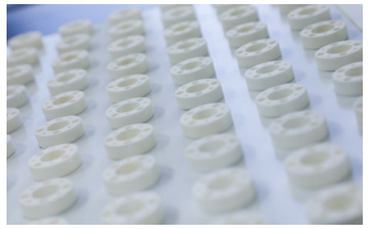
The fact that only a few applications from the field of ceramic 3D Printing have seen the light of day reflects the sensitive situation in which the young and still relatively small industry finds itself. The technology offers such great potential that many users are looking into it; they are building up expertise and seeking to gain a technological edge. At the same time, the process is complex and developing new applications is often laborious and time-consuming. »Our industry is a delicate plant that needs to be nurtured over the long term,« Gall says. »The potential is truly endless, especially when you consider that there are certainly many sectors and industries that have yet to discover ceramic 3D Printing,«

Text: Thomas Masuch

Images: Bosch Advanced Ceramics, Lithoz, Thomas Masuch, Mesago / Marc Jacquemin

Evove stacks these 3D-printed ceramic membranes into modules one meter in length

Opposite page:
Norbert Gall presents a filter membrane 3D-printed by Lithoz at Formnext
Below:
The mass production of ceramic components was another trending topic at Formnext, as D3-AM (left) and Lithoz (aerospike nozzles at right) demonstrated



adds Kareen Malsallez, marketing manager at 3DCeram Sinto, another renowned manufacturer of ceramic 3D Printing systems.

THE TECHNOLOGY

What often stands in the way of simple applications is the rather complex production technology. »Ceramic is a complex material that requires a great deal of expertise. It is not necessarily difficult to shape; the challenge lies in firing,« Malsallez points out. As with most other manufacturers of ceramic 3D printers, 3DCeram Sinto's SLA technology is based on a three-stage process in which a ceramic blank is first created, then debinded and fired at quite high temperatures in the third stage. The SLA process is a top-down stereolithography in which a ceramic slurry, which also contains a light-sensitive polymer, is exposed to a laser and partially solidified. The additives are removed in a second, thermo-chemical process. The rather fragile ceramic green bodies are then placed in an oven and baked at 1,000 to 2,000 °C. In Lithoz's lithography-based ceramic manufacturing (LCM), on the other hand, the slurry is exposed using light projectors, which means that the technology can be classified as digital light processing (DLP). Basically, the three-stage manufacturing process causes the components to shrink by around 3–30 percent, which must be considered in their designs.

Even though manufacturers such as Lithoz assure that shrinkage is »very well controlled via important parameters«, the entire process of 3D Printing ceramics is »even more complex than metal 3D Printing«, according to Nobert Gall. »The thermal processes of debinding and sintering in particular require a great deal of specialist knowledge.« To obtain the necessary knowledge, Lithoz customers can request a one-week training course in Vienna after purchasing a machine. »This is an absolutely key moment in the customer relationship,« Gall continues.

CUSTOMERS' AM KNOWLEDGE HAS GROWN

The international technology company Bosch has used its decades of experience in the conventional production of ceramic components to offer additively manufactured components, as well. Since 2016, Bosch Advanced Ceramics has been establishing a division that focuses on the industrial production of ceramic com- »

Many interesting discussions took place at the Formnext 2024 booth of Bosch Advanced Ceramics, whose large ring blades see use in handling wafers in the semiconductor industry

ponents at the company's Immenstadt site in southeast Germany. The division operates as a start-up under Bosch's own business builder, Bosch Business Innovations GmbH, and uses systems from 3DCeram Sinto and Lithoz in combination with a specially developed process monitoring system.

»The complex process is difficult to master, which is why our customers like to make use of our service to benefit from the advantages of ceramic 3D Printing,« explains Sabine Tulachan, who is responsible for marketing at Bosch Advanced Ceramics. Its customers come from the semiconductor, aerospace, adhesives, and medical technology sectors, among others.

Knowledge of the possibilities of Additive Manufacturing has generally increased, as Tulachan reports. »There are projects where the customer already knows exactly what they need. But there are also projects where we work together on design optimization in order to fully exploit the advantages of Additive Manufacturing.«

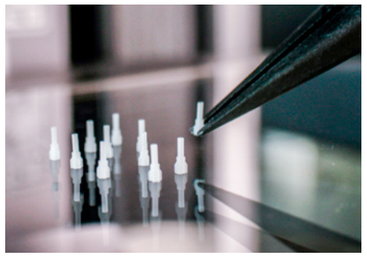
At Formnext 2024, for example, Bosch Advanced Ceramics presented a sleeve 3.5 mm thick with a wall thickness of just 0.09 mm, which reduces and improves the size of medical devices. According to Bosch Advanced Ceramics, the sleeve was developed in five months. In total, Bosch Advanced Ceramics now produces up to 50,000 such sleeves per year.

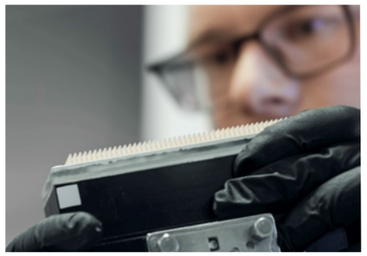
THE PLAYERS

Lithoz is one of the veterans of ceramic 3D Printing. Founded in 2011 by Dr. Johannes Homa and Dr. Johannes Benedikt, the company has around 150 employees and is still owner-managed. While it does not want to disclose the exact number of systems it has delivered to date, Gall says it is well into the three-digit range. He adds that Lithoz has »reached a critical mass« that is now enabling the company to approach the industry with reliable quality guarantees and offer systems for series production.

3DCeram Sinto has also been in business for many years. Founded in Limoges (France) in 2001, the company was originally active as a service provider – supplying 3D printed implants to the hospital in Limoges, for example, which, according to Kareen Malsallez, »are still in place today«. Its business model was later changed in 2017, when 3DCeram began developing and selling systems for the entire Additive Manufacturing process for ceramics. At the same time, Japan's Sinto

Bosch Advanced Ceramics also presented a sheath 3.5 mm in diameter whose material is just 0.09 mm thick, which makes smaller, more effective medical devices possible





Group became its main shareholder, with company founders Christophe Chaput and Richard Gaignon retaining shares in the company.

As the industry grows, more and more players are emerging. A few years ago, the Durst Group from Brixen (northern Italy) founded the subsidiary D3-AM GmbH, which presented its LABII printing system for micro particle jetting for the first time at Formnext 2023. Other companies, such as Amarea (a spin-off of Fraunhofer IKTS), Concr3de, ExOne, Nano Dimension (and its subsidiary Admatec), Voxeljet, WASP, and XJet, also offer printers that can be used to process ceramics. In addition, material suppliers such as the French company Nanoe SAS enable the FFF printing of ceramic blanks with special ceramic filaments.

Furthermore, the number of service providers is growing steadily. Steinbach AG and the US company Sinaptic, for example, have specialized in ceramics and use LCM technology from Lithoz. Service providers such as CADdent and the Japanese company Yugyokuen have also included ceramic 3D Printing in their technology portfolios.

For large system manufacturers such as Lithoz, qualified service providers play a very important role in spreading the technology. On the one hand, they often have machine parks of often five to seven systems, which makes them good customers that account for the majority of machine sales. At the same time, these service providers pave the way for the technology to become even more prevalent, as it is very rare for production companies to start out with their own ceramic 3D Printing systems. »You don't have to buy a printer straight away if you only need a small series,« explains Norbert Gall. »

This laser cap from Bosch Advanced Ceramics is designed to protect optical and electronic components from process residue and other contaminants

To make it easier for users to get started with ceramic 3D Printing, Lithoz has set up the Ceramic 3D Factory – a network of contract manufacturers that includes Bosch Advanced Ceramics, Steinbach, CADdent, Sinaptic (USA), and the two Japanese companies Mitsui Kinzoku and Yugyokuen.

APPLICATIONS

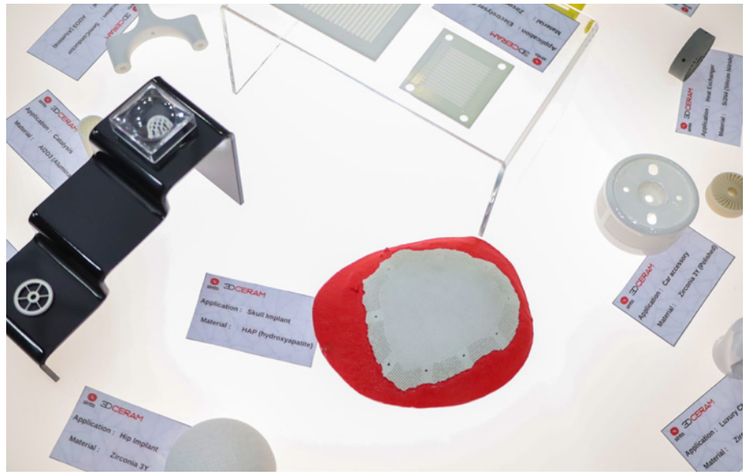
Once the technical hurdles have been overcome, ceramic 3D Printing will open up an enormous field of application. Here, the industries that are currently important to Lithoz are those that also play an important role in other areas of Additive Manufacturing:

- **Medical technology:** e.g. micro surgical devices with various functions (drills, probes, light channels, tubes for suction or tissue removal)
- **Space:** e.g. small nozzles for satellites, sensors and receivers (made of dielectric ceramics)
- **Aviation:** cast cores for turbines in which AM enables ever finer cooling channels, leading to better cooling of the turbines and ultimately lower fuel consumption
- **Semiconductor industry**
- **New energies**
- **Heat exchangers:** (found in many branches of industry) here, Norbert Gall describes aluminum nitride is »the star among heat exchangers« due to its high electrical insulation and optimal thermal conductivity
- Automotive industry: another area in which ceramics are an important topic for many OEMs, although the applications are not published

The decisive factor here is that ceramic 3D Printing creates real added value, as the complex production process does not necessarily make the components cheap.

Meanwhile, 3DCeram Sinto presented a promising project for the hydrogen industry a few weeks ago. The company has developed its latest, most highly automated machine, the C2000 Dualmatic, specifically to meet customer requirements for the production of corrugated plates that are components of the SOEC cells used to produce green hydrogen. The system, which was delivered in December 2024, has six lasers, each of which exposes two automatically alternating build platforms measuring 500 x 400 mm. This results in a high throughput that is designed to cover the high demand for ceramic cells. After all, a single SOEC cell requires 70 corrugated plates with internal channels measuring 163 mm x 130 mm and a thickness of a few millimeters.

»This marks the first time that an entire printing process has been fully automated for the mass production of larger components in the ceramics sector,« says a delighted Kareen Malsallez. At the same time, the C2000 Dualmatic machine is equipped with Ceria, an artificial intelligence developed over the past three years by 3DCeram.



Kareen Malsallez and Arnaud Roux from 3DCeram Sinto presented applications from various industries at Formnext 2024

Segments of an atomic layer deposition ring (or gas distribution rings) made of aluminum oxide that Lithoz unveiled for the first time at Formnext. The component's design originally came from Alumina Systems

HURDLES STANDING IN THE WAY

With so many successful applications and rather mature technologies, the question arises as to why the 3D Printing of ceramics has not long since outgrown its niche and is still »the little plant that needs careful nurturing«.

»Companies entering the 3D Printing of ceramics usually have to overcome a twofold challenge,« explains Nobert Gall. »They're not only switching from conventional to Additive Manufacturing, but also from metal to ceramic – a completely new material for many engineers.« Such a drastic change in technology can also be a venture.

In addition, the investment needed is higher than when getting into FFF printing, for example. The costs of the production technology – including sintering, an oven, and corresponding software – are in the six-figure range.

OUTLOOK AND OBJECTIVES

Overall, the major manufacturers believe their ceramic AM systems are ready for industrial use. »All of our references are real applications, including series production,« explains Norbert Gall from Lithoz. »We have already come a long way here and have covered most of the ground.« At the same time, Gall expects the range of applications to increase significantly over the next few years. »We have our foot in the door of many applications and industries.«

The Austrian company is doing everything it can to put the technology on solid footing. »Our goal is to enable customers to succeed with ceramic 3D Printing in the long term,« says Gall, who has also identified some black sheep in the industry. »We have competitors that we really appreciate, but also some that take a less solid approach to projects. If customers are then disappointed because their project was not feasible, they are not only lost to this manufacturer; they usually say goodbye to ceramic printing forever. In that case, nobody benefits at all.«

Overall, Lithoz's next step will focus even more on series production, and 3DCeram Sinto's future plans are heading in a similar direction. »We will continue to work on automating the process beyond printing and developing our Ceria AI while doing our best to transfer the technology to industrial players,« says Kareen Malsallez. If the industry continues to develop at such a steady pace, there will certainly be even more real-life applications to report on in the future.

+ FURTHER INFORMATION:

» lithoz.com
» 3dceram.com
» bosch-advanced-ceramics.com

IS THERE A FUTURE IN QUALITY?

Illustration: feedbackmedia.de, iStock/Elena Istomina, Kopirin, robuart

The word »crisis« has seen rather frequent use in the media of late – and probably more so in Germany than in other places. Even The New York Times has devoted several articles to the notion that our country has been particularly affected by the current downturn, with one bearing the headline: »Why Germany's Economy, Once a Leader in Europe, Is Now in Crisis«. The reasons for this economic decline are myriad, of course, and depending on whether you sympathize with the last German government, you probably blame either the geopolitical circumstances or home-grown failures in economic policy.

The areas in which Germany now leads the pack include energy prices, sick leave, and the amount of free time workers have. Across the world, no other country records fewer hours on the job: According to Globalhealth, the average time spent working in 2024 was 1,349 hours – far short of the hours turned in by employees in places like the United States (1,791), Poland (1,830), or South Korea (1,910). The youth of today don't offer much in the way of hope, either. A survey conducted by the consulting firm EY found that just 43 percent of Gen-Z employees give their all at work, far below the 63 percent ascertained for baby boomers (those born between 1950 and 1964).

Recently, futurologist Maximilian Lude delivered another figurative gut punch to those looking for some glimmer of optimism. He said that while business models geared toward quality and perfection have taken Germany a long way, they are no longer practicable given the speed at which the world now turns. »The future will be about finding perfection in imperfection,« Lude stated on the ntv production so techt Podcast.

And as if all that weren't enough, there was a shortage of rhubarb last year! Germany isn't one of the world's key rhubarb producers – think China, Belgium, and Spain – but it's hard to imagine restaurants all over the country having to take an item as popular as rhubarb spritzer off the menu. The weather had evidently been so detrimental to the rhubarb harvest that there simply wasn't enough of the refreshing beverage to go around.

Luckily, German artist Bode Wartke managed to produce something of a substitute in »Barbaras Rhabarberbar« (»Barbara's Rhubarb Bar«) – a groovy, tongue-twisting tune that stormed up the international charts, as well. While not many listeners outside of the German-speaking countries will understand the rather unique lyrics, they actually do rhyme perfectly. It just goes to show you that real quality is an art form in itself…

Text: Thomas Masuch

FonMag

RESPONSIBLY PRODUCED

SUSTAINABLE READING FOR A SUSTAINABLE FUTURE

Print can inform, advertise and be green: Formnext Magazine does not generateany e-smog. Print is also perfect for slowing the pace and digitally detoxing. Printed medium still has a lot going for it.

In order to live up to our responsibility for the future, we examine the current possibilities for each issue and do everything we can to produce the Fon Mag in the most environmentally friendly way possible:

- We use paper from sustainable forests.
- We do not use environmentally harmful processing to optimize the printing result.
- The Fon Mag is sent climate-neutrally to the readers.
- With each production run, we support a selected reforestation project to preserve the analog, environmentally friendly reading experience.

Our partners for an environmentally friendly Fon Mag are listed below in the imprint.

Detailed information on our sustainability strategy at **formnext.com/sustainability**.

formnext

» 18 – 21 November 2025
» Messe Frankfurt, hall 11, 12 and Portalhaus

CONTACT:
» Hotline: +49 711 61946-810
» formnext@mesago.com
» formnext.com/fonmag

SAVE THE DATE:
» 17 – 20 November 2026
» More information: formnext.com

IMPRINT Fon Mag Issue 01/2025

PUBLISHER
mesago
Messe Frankfurt Group

Mesago Messe Frankfurt GmbH
Rotebühlstraße 83 – 85
70178 Stuttgart, Germany
Phone +49 711 61946-0
info@mesago.com
mesago.com

Register Court Stuttgart,
HRB Stuttgart 1 33 44
VAT-Identification Number:
DE147794792

Responsible for content under German Press Law: Sascha Wenzler

PROJECT COORDINATION
Nina Schwarzer
Phone +49 711 61946-566
Nina.Schwarzer@mesago.com

EDITED BY
ZIKOMM – Thomas Masuch
thomas.masuch@zikomm.de

DESIGN
feedbackmedia.de

PRINTING
Druckhaus Stil + Find,
Leutenbach-Nellmersbach

PUBLICATION FREQUENCY
Published four times per year

CIRCULATION
18,700 copies

ADVERTISING
Mesago Messe Frankfurt GmbH
Phone +49 711 61946-501
Stefan.Rapp@mesago.com

SUBSCRIBE TO FON MAG
formnext.com/fonmag

READER SERVICE
formnext-magazin@mesago.com
Phone +49 711 61946-405

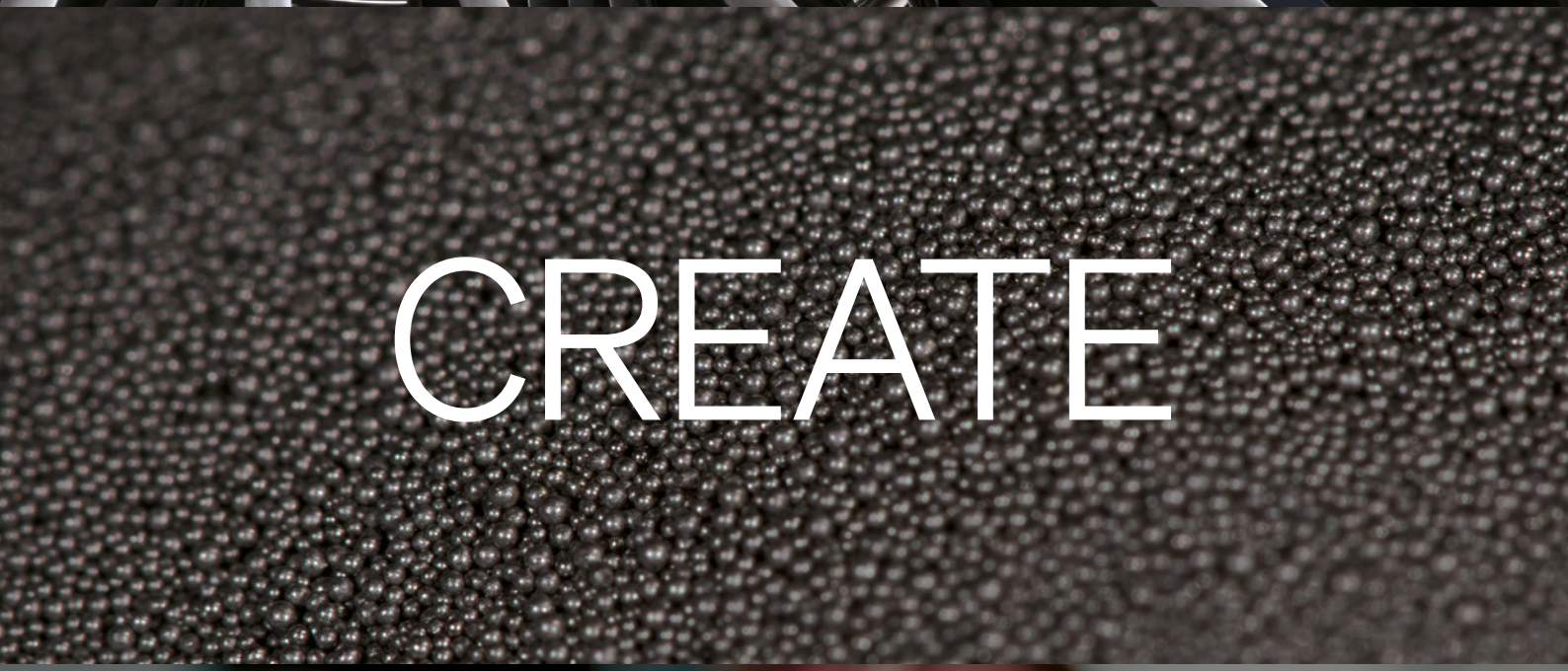
Our partners for a responsibly produced Fon Mag:

FSC www.fsc.org MIX Paper | Supporting responsible forestry FSC® C158404

natureOffice natureOffice.com/DE-662-2FKJM4T Materials Transport Production g CO2e per 205,24 print product CO2e-emissions compensated

By using the QR code or entering the project ID at **natureoffice.com**, you can find out which forest project project the current FonMag is supporting.

More information at **fsc.org** and **natureoffice.com**.



COLIBRIUM ADDITIVE
a GE Aerospace company

As one of the leading experts on additive manufacturing, we live to craft the impossible, time and time again.