

Fon Mag

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

A LONG AND WINDING ROAD

Developing special materials takes a lot of effort, but the opportunities are worth it

Page 10

IMPROVING READINESS

AM continues to gain importance in the marine sector

Page 16

mesago

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In my whole life, I have known no wise people over a broad subject matter area who didn't read all the time – none, zero.



[Charles T. Munger, 1924–2023, former Vice Chairman Berkshire Hathaway Inc.]

Cover: Mesago / Mathias Kutt

EDITORIAL

Judging by the various developments of regions and industries, the world seems to be taking on more and more of a multipolar character. Just look at India's airlines, for example, which have ordered nearly 1,200 aircraft over the past 12 months – that's more than twice as many as their counterparts in the United States, and more than 10 times the number ordered by German airlines. On average, India is projected to build a new airport every single month in the coming years. Things are literally taking off on the subcontinent, while in other countries – including Germany – the economic outlook has turned somewhat cloudy. Ongoing geopolitical dilemmas like the war in Ukraine and disruptions in supply chains have recently been joined by threats in international waters.

These developments are also affecting the world of AM, of course, although market researchers are still predicting healthy growth for the industry as a whole. That said, AM is actually something of a mixed (or perhaps »multipolar«) bag. While the most recent survey conducted by the German industry association VDMA revealed rather sober projections in AM and mechanical engineering, a variety of smaller and specialized AM manufacturers reported record sales.

Either way, I don't think anything will stop the continued advance of AM. It's enabling so many different sectors to gain so many different advantages. With AM, companies can maintain a competitive edge even during economically challenging periods.

For more proof of why AM seems destined for long-term success, look no further than the outstanding registration numbers at Formnext. In this issue of Fon Mag, we've also explored a series of exciting topics that form the foundation for the technology's further progress. Along with the challenges in material development, they include growth opportunities in Eastern Europe and the marine sector. You can also take part in our reader survey (page 5) help us stay even more in tune with the latest developments.

Like the entire AM community, I'm very much looking forward to a thrilling 2024 – and to this year's trade show in November, of course! As the world becomes an increasingly multipolar place, Formnext in Frankfurt (and the corresponding brand events in China, Japan, and the United States) will continue to give the »fAMily« a home and help add to our industry's already considerable success.

Sincerely, Sascha F. Wenzler
Vice President Formnext



CONTENTS

10



16



05 FORMNEXT NEWS
» Reader survey – Fon Mag online

06 FORMNEXT REVIEW
» Nano Dimension · Brake discs · Product launches · Architecture and construction · Partnerships · Machine sales · Prima Additive · Sustainability in Chemnitz · Mosaic

10 A LONG AND WINDING ROAD TO NEW POWDERS
» Materials are the key to new applications

14 DOUBLE-DIGIT GROWTH ALONG THE DANUBE
» The AM industry is booming in Eastern Europe



14



19

16 IMPROVING READINESS
» AM continues to gain importance in the marine sector

19 SOMEWHERE BETWEEN PAINTINGS AND OBJ FILES
» The artistic duo Sutosuto is incorporating 3D Printing into more and more projects

22 OUTSIDE THE BOX
» Grapes worth waiting for

FORMNEXT NEWS

FON MAG READER SURVEY

Just like the «fAMily» is integral to every Formnext, making resolutions is part of the start of every new year. In 2024, we've resolved to make Fon Mag even better. Since last year, our reader survey has given you the chance to share your preferences and suggestions for our magazine. Many of you have already taken advantage and provided us with some very helpful feedback, including plenty of exciting ideas. We'd like to thank everyone who has taken a few minutes to send us their thoughts (and criticism!) to help us align Fon Mag with the needs of our community. It's the only way we can improve!

Haven't gotten around to it yet? You still have time to give us your input for future editions of Fon Mag. For now, this year's first issue will be the last chance to participate in our reader survey.

ANOTHER GOOD REASON TO TAKE PART

Every time we produce an issue of Fon Mag, we support a specific climate protection project. To thank you for your input, you'll also receive a small climate protection project of your very own, or we'll give you the chance to vote for the project the next edition of Fon Mag should support.

We'd love to hear from you!
Tell us what you think at



» formnext.com/survey

RECORD RESULTS

Formnext continued its remarkable run of success in 2023, having welcomed 32,851 managers and other professional attendees (half of them from outside of Germany) to Frankfurt am Main from 7 to 10 November. It thus drew 11.1% more visitors than in 2022, which was already a very strong year. The 859 exhibitors Formnext attracted in its ninth year (59% of them from outside of Germany) set a new record, as well. The companies in attendance, along with the event's numerous events and special showcases, highlighted the myriad possibilities Additive Manufacturing offers in a wide range of user industries. »Having so many innovations, decision-makers, and AM experts all in the same place provides for a unique trade show experience you just can't compare to anything else,« declared Sascha F. Wenzler, Vice President of Formnext at Mesago Messe Frankfurt GmbH. Formnext was also able to bolster its position as the global leader, with 73% of last year's exhibitors calling it one of the industry's most important exhibitions. Meanwhile, a full 91% of them described being happy or very happy to have taken part. That figure was even more impressive among last year's visitors (96%). To check out a selection of trends and personal impressions from Formnext 2023, turn to pages 6 – 9.

Other exciting facts and statistics are available in a detailed analysis of Formnext at » formnext.com/analysis



A DIGITAL VERSION OF FON MAG?

There's one thing we've received feedback on in our reader survey that we can address right here and now: Yes, Fon Mag is also available digitally! You can enjoy our articles online whenever you like at our website or download the issues in PDF format. In addition, all our magazine articles can be found in the AM4U newsletter, which also includes the latest online articles and exciting videos from

Formnext.TV. You can set your preferences by requesting a profile link and choosing between our digital newsletter and the printed edition. We are of course also happy to send our AM Industry Insights to new subscribers. When registering, choose whether you would like to receive it in print (Fon Mag) or digitally (AM4U newsletter).

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FORMNEXT REVIEW

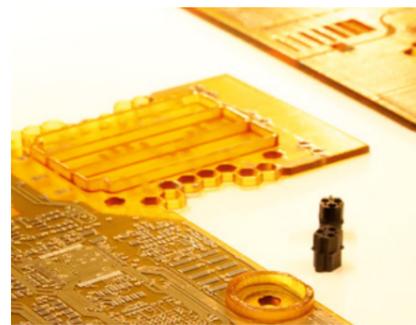
NEW MOMENTUM THANKS TO TINY COMPONENTS



With printers and special materials from the Fabrica Group, Nano Dimension wants to make all-new applications at the micro level possible – even beyond printed electronics. The Israeli company presented numerous components at Formnext, including tiny screws that can replace metal parts in the manufacture of smartphones, for example. »Until now, it was impossible to make such components from plastic,« explains Nir Sade, GM AM, SVP Product Champion. The Technology House, a contract manufacturer from the US state of Ohio, has become a believer in the technology after beta-testing the company's Tera machines

and now using it for two years. »Micro 3D Printing is giving a new boost to product development,« explains CEO Chip Gear. »Components are getting smaller and smaller, and ultimately, so are the overall products. There's a lot of potential for the aerospace industry, for example, but also for other sectors.« Gear and his daughter, Tracy Brent (president of The Technology House), spent three days taking in the innovations at Formnext in Frankfurt. »This is the right place to see the developments and advances within the AM market. At Formnext, we were able to experience a wide variety of systems and materials bundled together and efficiently in one

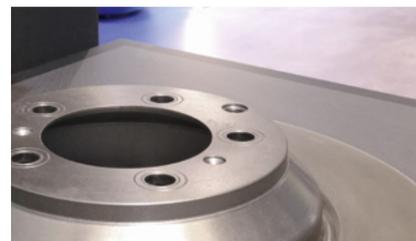
place,« Gear continues. »This gave us the opportunity to find and select the most suitable solutions for our production.« Founded in 1987 and now employing 85 people, his company has built up an impressive AM machine park that includes numerous printers from the likes of HP, Carbon, and 3D Systems. On a production floor spanning around 500 square meters, components are also conventionally milled or manufactured using injection molding or EDM processes. AM components now account for 30 percent of The Technology House's turnover, and Brent and Gear want to increase this further. However, there are still challenges to be overcome in nano technology, especially in post-processing. »How do you clean the components, and how do you measure them?« Brent points out. »That said, we're already seeing important improvements on the market.« Nano Dimension finished beta testing its Tera machines more than a year ago and has already installed 10 systems, as Nir Sade reports.



HOTLY DEBATED DISCS

Applications from the automotive industry also played an important role at Formnext 2023. For example, brake discs (some with corresponding coating technology) featured quite prominently at the booths of renowned companies such as Trumpf, Prima Additive, and materials supplier Mimete. These discs are currently a hot topic in the automotive industry,

as manufacturers of cars, vans, buses, and trucks must implement the new Euro 7 emissions standard by July 1, 2025. This will place new demands on the coatings of millions of brake discs – and Additive Manufacturing is a great way to take on the related challenges.

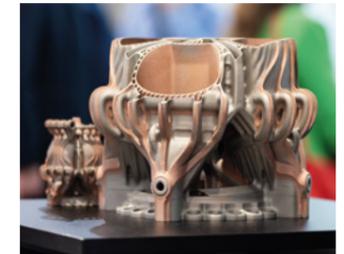


Images: Thomas Masuch

FORMNEXT REVIEW

CELEBRATED INNOVATIONS

The world's leading AM companies use Formnext to present their latest innovations, as the 2023 edition once again confirmed. It featured numerous product launches, some of which were celebrated with elaborate shows and met with a great deal of interest from experts. At the Stratasys booth, for example, CEO Dr. Yoav Zeif presented the F3300 for the first time. With this new FDM printer, the company is promising 25 percent lower costs per part, twice the throughput of conventional FDM printers, and 25 percent higher accuracy. Markforged president and CEO Shai Terem also traveled to Frankfurt to present the new FX10 to a large audience. According to Markforged, the FX10 is optimized for the on-demand production of spare parts and tools and uses various automation functions to simplify the printing process.



Cover image
Multimaterial applications were one of the top trending topics at Formnext 2023. They are opening the door to more and more uses that were previously impossible in the desired dimensions, including the aerospace rocket engine pictured here. Ideas involving this extraordinary propulsion design are nothing new, having been the subject of research since the 1950s. However, it appears that they were waiting for Additive Manufacturing to arrive and make this technological work of art possible. The engine above was presented by the Fraunhofer Institute for Casting, Composite, and Processing Technology (Augsburg). It was manufactured from a combination of maraging tool steel (1.2709) and the copper alloy CW106C using an LPF process.

CONCRETE DRAWS A CROWD

Construction is currently one of the biggest growth areas in Additive Manufacturing. This was also evident at Formnext 2023, where, in addition to the established BE-AM special show in Hall 11.0, Formnext presented a new special show for the construction industry in cooperation with Constructions3D. The area, which proved to be a real attraction throughout

the trade fair, featured live production of concrete elements used in house construction. And the French company was not the only exhibitor to exhibit solutions for the construction industry. Visitors also had the chance to marvel at numerous innovative solutions for current and future construction challenges at the aforementioned BE-AM showcase. Jörg Petri, founder and direc-

tor of NewDigitalCraft, presented 3D printed models that are used in the renovation of old buildings, for example. These can be used to create concrete elements that look just like materials from a bygone era, making them a comparatively inexpensive alternative to sandstone elements.



Images: Stratasys, Thomas Masuch, Mesago / Mathias Kurt, Mesago / Marc Jacquemin

FORMNEXT REVIEW

DEVELOPING NEW APPLICATION AREAS TOGETHER

As in most other areas, budgets are not unlimited in Additive Manufacturing. This is a key reason why the conviction that certain new developments can be better shouldered together – to spread out costs and exploit synergies, for example – seems to be gaining ground. A number of new cooperation projects were presented at Formnext 2023. The most prominent of these was certainly the Additive Manufacturing Industrialization (AM I) Navigator initiative, which aims to guide AM users through the increasingly complex AM landscape with tailored advice. The project is a collaboration involving Siemens, DyeMansion, BASF Forward AM, EOS, and HP. However, there have also been exciting developments on a smaller scale, such as the cooperation agreement between Fraunhofer IGCV and Nikon SLM Solutions AG, which are aiming to strengthen their collaboration in multimaterials. Their current research focuses on industrial applications for the aerospace, automotive, toolmaking, and jewelry industries, among others.

The photo shows (from left to right): Dr. Georg Schlick, Head of Department, AM Metal and Multimaterial, Fraunhofer IGCV; Simone Castellani, CTO, Nikon SLM Solutions; Prof. Dr. Christian Seidel, Head of the Research Field Additive Manufacturing; and Dr. Simon



Merkt-Schippers, EVP of Product Management, Nikon SLM Solutions. The post-processing specialist Rösler has also announced partnerships with EOS, FKM Additive Manufacturing, and Shapeways.



NEW MACHINES TO MEET GROWING DEMAND FOR AM PARTS

The importance of Formnext as a business platform was clear once again at the trade fair grounds in Frankfurt this past November. The many booths offered space for not only technical discussions, but concrete agreements and business deals, as well. For example, the Italian start-up Extreme Manufacturing Engineering (EME, which was just founded last year), purchased two large-format SLM machines at Formnext 2023. With the two machines (a BLT-S800 and a BLT-S450), EME aims to »meet increasing demand for additively manufactured parts in Europe, especially in automotive, consumer electronics, medical devices, and other applications, including structural parts for amusement rides,« states managing director Eddi Tomat. The Austrian company Lithoz, which specializes in the 3D

Printing of high-performance industrial ceramics, also pulled off its first direct sale of a machine at the most recent Formnext. »That had never happened for us at a trade fair before. It was also surprising; we normally have quite a long sales cycle because the 3D Printing of indus-

trial ceramics still requires a lot of explanation,« reports Nibert Gall, head of marketing and PR. »But this customer – one we'd had only sporadic contact with previously – approached us directly at the trade fair with a request to sign a purchase agreement.«



Images: Thomas Masuch, BLT, Lithoz

Images: Thomas Masuch

FORMNEXT REVIEW

INGENIOUS LASER COMBINATION

The name alone let everyone know that Prima Additive had brought something very special to Formnext in Frankfurt. In the Print Genius 150 Double Wavelength, the Italian AM system manufacturer has designed a printer that works with two lasers of different wavelengths: a 500-watt infrared laser and a 200-watt green laser. According to Prima Additive, the ability to alternate between the two lasers in the same work area means that the Print Genius 150 can work with conventional materials such as steel, aluminum, nickel,

titanium, and cobalt-chrome alloys thanks to the infrared laser, while the green laser makes it possible to process highly reflective materials such as pure copper or precious metals. Overall, marketing manager Daniele Grosso was highly satisfied after Prima Additive's four eventful days at Formnext 2023. »We generated a high number of contacts, and we're happy about the frequency and quality of visitors that came to our booth,« he affirms. »People are demonstrating more and more knowledge of the technology; they are asking technical questions and

are more and more likely to be the ones making decisions at their companies.«



WOOD CHIPPINGS AND COTTON LINT



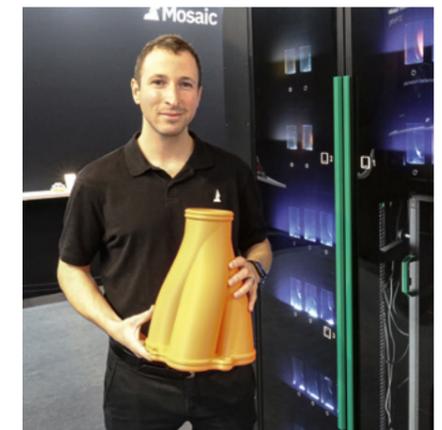
Sustainability is something that Dr. Lisa Kühnel (TU Bergakademie Freiberg, left) and Adelina Berkemeier (Chemnitz University of Technology) are passionate about. That's why the two scientists are working together on the SAMSax (Sustainable Additive Manufacturing Saxony) project, which is researching ways to make use of residual products from industry

and agriculture by means of additive techniques. At their booth, they presented a series of sustainable materials, such as wood chippings, coffee skin, cotton lint, and paper dust. Kühnel and Berkemeier also brought news of an initial successful application to Formnext: Wood chippings had been used to 3D-print stage props for Chemnitz's municipal theater.

SCALING UP 300 AUTOMATED AM SYSTEMS FOR JUST-IN-TIME PRODUCTION

Greater cost-effectiveness can be influenced by two factors in particular: automation and higher printing speeds. Almost all the major system providers now offer automation solutions. At the most recent Formnext, 3D-Ceram, AM-Flow, Mosaic, and many other smaller, specialized companies also showcased tailored offerings (including software) for the entire process chain. These solutions clearly meet the needs of the market. Mitch Debora, co-founder and CEO of Mosaic Manufacturing, reported at Formnext that his company's array machine has already gained a strong foothold with customers.

Mosaic is working with several enterprise partners, the largest of which is planning to scale up to over 300 arrays for just-in-time end part production. Mosaic's presence at Formnext also played a prominent role in establishing the company's machines on the market, as Debora affirms: »We met the right partners from all over the world. The interest was overwhelming; at our booth we had lots of people with buying power.«





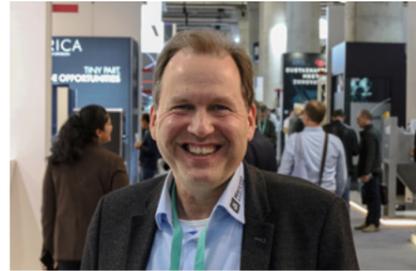
A LONG AND WINDING ROAD

Materials are the key to new applications that will lead to more widespread use of Additive Manufacturing. The number of different powders available is rather limited, however – especially in metal 3D Printing. While the demand for new materials is definitely there, the process of developing them is complex and expensive.





Photos: Magda Perez Gila, Nico Geis, and Harald Lemke were among those showcasing their companies' material expertise at Formnext 2023



Text: Thomas Masuch

Those who work in metal 3D Printing have a few dozen standard materials at their disposal, ranging from various types of steel to copper, titanium, and aluminum alloys and even cobalt and tungsten. »Plenty of OEMs and tier-one companies are looking for alternative materials in small volumes,« reports Dr. Haneen Daoud, deputy head of the metals division at Neue Materialien Bayreuth (NMB). »Powder manufacturers, however, are only willing to produce large quantities.« At the moment, she is seeing the most demand for special materials (see definition page 13) in the aviation industry, renewable energy, hydrogen and thermal energy, and electromobility. Institutes like NMB specialize in developing and manufacturing powders in the smaller quantities companies need. »This enables them to carry out feasibility studies and bring new products to market,« Dr. Daoud explains.

Creating a special material for use in AM isn't exactly easy, though. Nico Geis, a technology transfer expert at NMB, estimates that it takes around three to four years to develop a new metal alloy for Additive Manufacturing. »At the same time, the current market for special materials in AM is small in terms of volume,« Geis reports, which is why not many investments are being made in this sector.

The customers that commission NMB to come up with new materials are often midsized companies that leverage the resulting research to expand their production expertise (which they

then keep in-house). In other words, there may be any number of new AM solutions and materials out there already; they're just not on the open market. For many companies, research of this kind is tremendously important when it comes to gaining a competitive edge. »It's often what gives rise to the DNA at the heart of the next generation,« Geis reveals.

USING LESS ENERGY AND RAW MATERIAL

Dr. Daoud reckons there are around 10 to 20 special materials on the market. It's also hardly unheard of for different companies to be developing the same powders at the same time. »Users are often working toward the same goals to improve the characteristics of things they're already selling,« she says. In developing new materials, firms are often looking to overcome similar challenges, such as the need to save energy and raw materials or increase the useful life of their products.

The successful applications NMB has realized with special materials in AM include pump components, seals, and turbine parts that need to withstand extremely high temperatures (around 700° C). In these cases, the institute has made use of titanium-, nickel-, and cobalt-based materials that are either difficult or impossible to weld, but offer high creep resistance, the desired thermomechanical properties, and very good resistance to oxidation. »Without these materials, we wouldn't have been able to achieve those characteristics,« Dr. Daoud says.

FIVE VARIANTS OF ONE SUPERALLOY

Another way to find the right material for a particular use case is to conduct a series of targeted experiments, explains Magda Perez Gila, communication manager at Mimete. After identifying five variants of a nickel superalloy that suited its purposes, an OEM ordered small batches of the variants from this Italian producer of AM powders. Some initial tests of the materials' compatibility with laser powder bed fusion (LPBF) were conducted, and one variant was then selected for further testing. Following additional analysis (including with larger batches), the metal powder in question made a successful transition into production.

CAREFUL CONSIDERATION REQUIRED

When you talk with Harald Lemke, you quickly realize why the development of new materials is anything but a straightforward endeavor. As director of product management at MacLean-Fogg Component Solutions, Lemke develops and brings to market types of steel that are specifically designed for AM-based tool-making. He says he hears calls for »advanced materials« all the time at industry conferences. »To succeed in developing and commercializing materials like these, however, you have to make some very detailed considerations,« he points out.

Lemke is aware of a number of advanced LPBF materials that are »in the pipeline« in spite of the significant challenges involved. The num-

Images: Thomas Masuch, Mimete

Defining special materials

Special materials combine various properties (such as hardness, ductility, or resistance to rust) to offer the best possible solution for a particular set of requirements. (Harald Lemke)

Special materials are designed for requirements or applications where the standard materials available don't offer an adequate solution. (Nico Geis)

ber is quite small, though, and materials like these are typically only used in small quantities, which he attributes to the long lead times and test cycles in material development. »The development costs are often too high, and the commercialization process takes too long,« Lemke affirms. Considering how niche most of the current markets are for which such materials can be optimized, he says it's virtually impossible to turn a profit.

»That's why it's no wonder end users still mainly use conventional materials for most LPBF applications,« he continues. »Until such applications seem scalable, we won't see evolutionary improvements that optimize the alloys for LPBF.« According to Lemke, modifications like these can be found in nickel and titanium alloys in particular, as well as in alloys of aluminum and steel.

A HIGH DEGREE OF EFFORT

For Dr. Daoud, meanwhile, the significant amount of work involved in developing special materials stems from the unique aspects of 3D

Printing with metal. For one thing, the corresponding material systems are usually not available in the form of wire or powder. The parts produced also tend to cool quickly, which leads to cracks and severely limits the feasible size of additively manufactured components. And as if the whole undertaking wasn't already complicated enough, the properties of atomized powders vary a great deal from producer to producer. »That sometimes means having to spend a lot of time adjusting your process parameters,« Dr. Daoud says.

DIFFERENT APPROACHES TO RESEARCH

NMB's research on new materials takes place either as part of doctoral theses or in bilateral research projects that are financed by one or more companies. Efforts to solve »larger issues« of a fundamental nature can also be eligible for public funding. Here, NMB handles the actual material development up to the point of small series production, which includes relevant methods of characterization. The requests it receives come from both companies interested in using the resulting materials and firms that produce or supply materials themselves.

»Before you start developing a new material, you have to ask yourself a number of different questions,« explains Nico Geis. »How much effort will the project take? Is there a market that's willing to pay for the material? And along with the economic aspects, the question of how a new material performs in a lifecycle assessment is one that's coming up more and more in

market research.« For example, it's an advantage in terms of both economics and energy if the gases used in a given process can be recovered and refined by means of corresponding system technology.

The research projects at NMB – which cover plastics, as well – also try to find ways to come up with solutions faster by means of more intelligent processes. »In some cases, we don't even need a new material,« Geis says. »We can reach our objectives with coatings, surface finishing, multimaterial printing, or hybrid materials.« Sometimes, a new production process also leads to new results. Take the time NMB combined two unalloyed materials in wire form in a DED process, for instance, in a targeted effort to achieve better material characteristics for specific use cases – all without using adapted raw materials. »Nothing is impossible in chemistry, but you do have to think things all the way through, including with regard to processing and the eventual application at hand,« Geis says.

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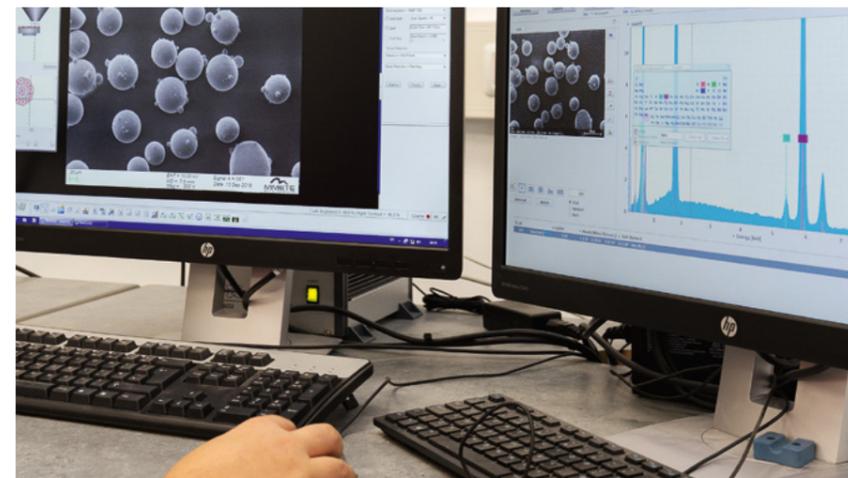


Photo: Mimete's lab examines the structure of powder at the microscopic level

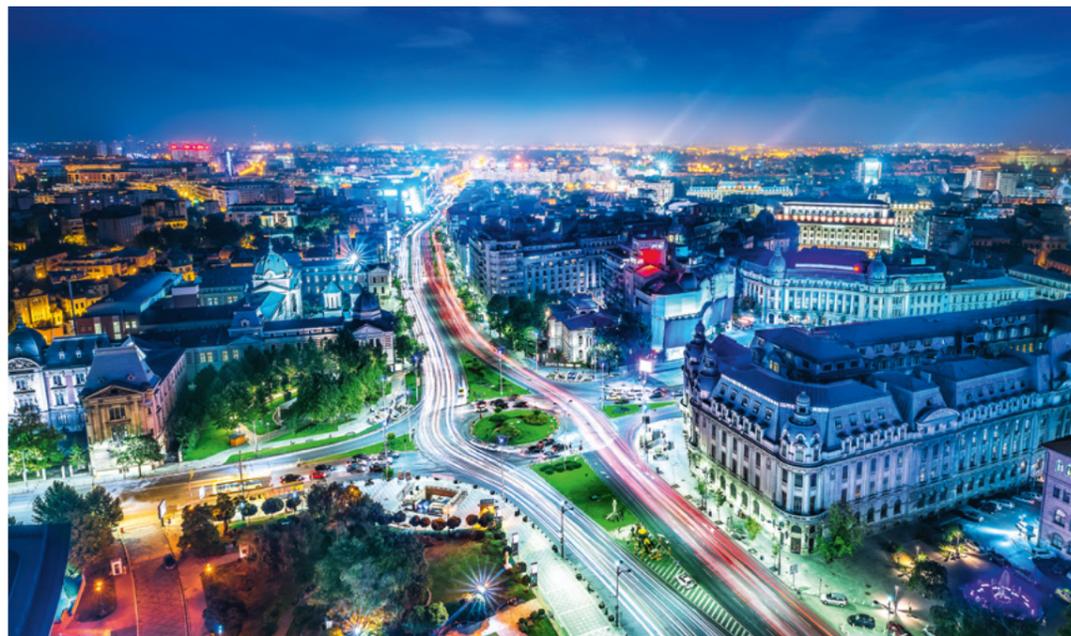
DOUBLE-DIGIT GROWTH ALONG THE DANUBE

The AM sector in Eastern Europe is booming thanks in part to a dynamic economic environment.

Poland is probably the leading Eastern European country in the field of Additive Manufacturing. Not only do numerous innovative start-ups and renowned companies such as Sinterit and Zortrax come from here; a total of 15 exhibitors from Poland were represented at Formnext 2023, including Progresja New Materials, a winner of the Formnext Start-up Challenge.

In addition, international AM service providers such as Align Technology have set up production facilities in the country. The Czech Republic has also developed successfully as an AM location. In addition to Prusa, it is home to numerous material manufacturers. At the same time, 3D Printing is playing an increasingly important role in countries such as Hungary,

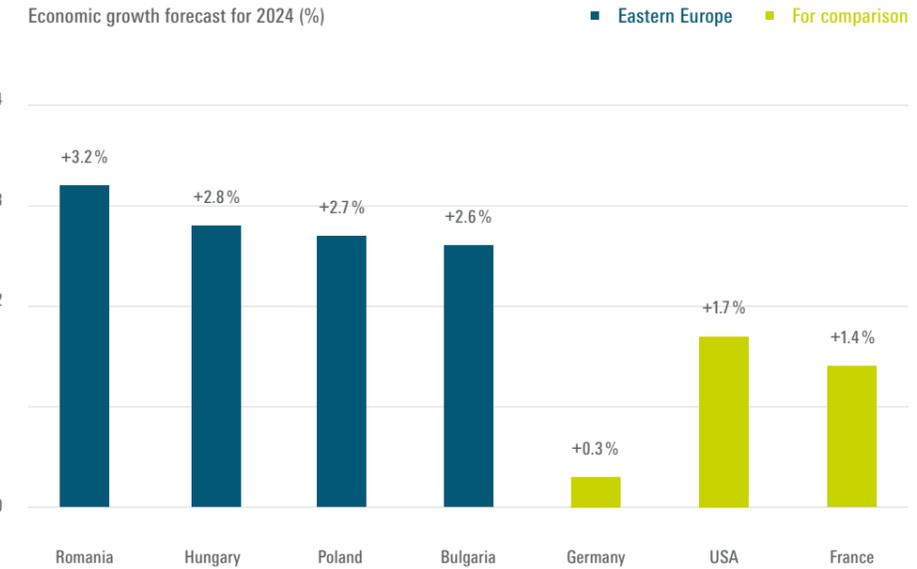
Romania, Bulgaria, and Greece. In Romania, for example, Additive Manufacturing is taught at universities (including in Brasov, Bucharest, and Cluj), and high-performance service providers such as NUT Technologies and CAD Works have also established themselves here. In the countries of southeastern Europe, Additive Manufacturing is »in a phase of dynamic



Bucharest and its 1.8 million inhabitants play a leading role in Romania's dynamic economy

Text: Thomas Masuch

Image: iStock /frankpeters



Sources: EBRD, BDI, US Federal Reserve, French Ministry of Finance

growth,« explains Costas Andronikidis, who has a very good overview of the region as general manager of the Greek AM distributor Anima. »Even though 3D Printing in these countries has not yet reached the same stage as in Western Europe, the upward trend in the implementation and use of AM is significant and the number of applications is steadily increasing.«

EXHAUST MANIFOLDS AND BONE FILES

According to Andronikidis, small and medium-sized enterprises (SMEs) are the main drivers of this development. The key sectors include the automotive, aerospace, healthcare, and consumer goods industries. In the automotive sector, companies (such as the Romanian software developer CryptoData and its MotoGP team) use 3D Printing for prototyping and the production of finished parts. »Things like exhaust manifolds are 3D printed from durable and heat-resistant materials, resulting in lighter, yet robust designs that can withstand the extreme temperatures and pressures in exhaust systems,« Andronikidis continues.

The benefits of AM are also being researched and leveraged in healthcare – for instance, to produce medical devices that are tailored to the individual needs of doctors and patients. »One notable example of this is a project in Greece where a special medical tool – a bone file – was 3D printed,« Andronikidis

reports. Due to its small size and complicated design (which included specific angulation for the notches), the bone file was very difficult to produce using conventional methods.

ONGOING GROWTH OF 20 TO 30 PERCENT

Andronikidis expects the AM market in Eastern Europe to continue its rapid growth. »We expect an annual growth rate of 20 to 30 percent over the next three to four years. And if there are further technological developments, which we expect, this rate could continue for up to 10 years.«

It bears mentioning that the development of the AM world in the region is benefiting from economic growth that is very solid in general, and much more dynamic than in most Western European countries. A rate of 3.2% is expected in Romania in 2024, followed by Hungary (2.8%), Poland (2.7%), and Bulgaria (2.6%). In comparison, expectations for Germany are significantly lower at 0.3%, while 1.7% is expected for the USA and 1.4% for France.¹

DIVERSIFICATION OF SUPPLY CHAINS

Among other things, economic development is being driven by the efforts of Western European companies to diversify their supply chains (through nearshoring). Central and Eastern Europe are seen as reliable locations, which makes them preferred regions for companies

looking for suppliers. Eastern Europe in particular makes compelling arguments thanks to its motivated workforce and low labor costs. In Bulgaria, an hour of labor costs less than €10 on average, whereas companies in Germany charge around four times as much. Business Park Sofia, which is more reminiscent of a modern industrial campus in the USA, is an example of the modernization in the region. International corporations such as Sony, HP, Unilever and KPMG have set up shop here.

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IMPROVING THE OPERATIONAL READINESS OF SHIPS



Given the limited production quantities involved, you'd think the marine industry would be a prime sector for 3D Printing. In recent years, however, the development of Additive Manufacturing in this area has not really progressed at a rapid pace. Now AM seems to have arrived on the water: Entire boats are being printed, and the leading nations have launched naval projects on how AM can be installed on ships.

As the German Navy's 3D Printing coordinator, Lieutenant Captain Dr. Sascha Hartig is responsible for implementing Additive Manufacturing within this branch of the military. In just seven months, Hartig and his team have found 153 use cases, most of which involve small plastic parts where 3D Printing »helps improve the operational readiness of a ship,« as he puts it. Usually, replacements for defective components are 3D printed and remain in use until a ship arrives at the next supply port, where original spare parts are available. The German Navy has already received praise for this new technology from the highest level: »The introduction of 3D Printing marks the beginning of a new era for the Navy in terms of improving spare parts availability and

spontaneous response to emergency repairs,« said Vice Admiral Jan Christian Kaack, the navy's inspector.

The German Navy has had printers on board for several years now. They were initially used for research, but are now serving more and more practical purposes, such as in producing valves for wastewater treatment or housings for electronic components that are no longer available from the manufacturer after 10 years. The printers also make seawater filters made of nylon – which, unlike steel components, do not corrode – and temporary components for the fire extinguishing system.

In another case, a blind flange for a dismantled heat exchanger in a ship's seawater cooling system was printed at sea. This fixed

a defective valve that had been allowing 180 liters of water to leak into the ship every day.

In addition to repair options like these, Hartig uses 3D Printing to print prototypes, for example, and thereby leverages Additive Manufacturing as a driver of innovation for the military. »This sometimes brings a gleam to the soldiers' eyes,« he reveals. In the future, Hartig wants to significantly expand the German Navy's use of AM. One key here is networking and the international development of standards. Among other benefits, ships will then be able to supply each other with temporary components from their 3D printers during international maneuvers, meaning not every ship will need to have a full range of AM parts on board.

Text: Thomas Masuch

Images: Ramlab, Mesago / Mathias Kurt

PROPELLERS AND UNDERWATER HABITATS

Based in the port of Rotterdam, Ramlab is one of the companies with the most AM experience in the marine sector. The company focuses on wire arc Additive Manufacturing (WAAM) and 3D printed the WAAMPeller back in 2017 – »our best-known shipbuilding part«, as CEO Vincent Wegener describes it. The world's first 3D printed and certified propeller, which weighs 220 kilograms and has a diameter of 150 centimeters, was created in collaboration with Damen Shipyards, Promarin, Autodesk, and Bureau Veritas. Since then, Ramlab has worked with the Royal Netherlands Navy and DNV on printing a stainless-steel impeller and was involved in 3D Printing the first high-pressure components for Vallourec in the oil and gas industry. Its

current project, meanwhile, is underwater:

Six robotic MaxQ systems arranged in a hexagonal configuration are being used to create the world's first 3D printed underwater habitats for humans. The robots synchronously produce the hull segments, which weigh more than 30 tons and are subsequently certified by DNV.

APPLICATIONS ON THE RISE AROUND THE WORLD

Additive Manufacturing can now also be found on more and more naval vessels worldwide. The Indian Navy, for example, has printed a centrifugal pump impeller together with the 3D Printing service provider think3D, and the Australian Navy has purchased a WarpSpeed3D metal printer to improve the maintenance of

patrol vessels. 3D printers are also in use on US Navy ships: The USS New Hampshire, for instance, has had a Markforged X7 Field Edition on board since July 2022, which it has used for things like fixing leaking pipes and printing electronic housings. The 257-meter-long USS Bataan has also employed a Phillips Additive Hybrid to 3D-print and post-process a nozzle for a saltwater outlet valve.

Additive Manufacturing is also playing an increasingly important role in shipbuilding itself, even if many projects are still in the development stage. For example, the US Navy is working with the Australian AM company AML3D on the construction of submarines, which involves manufacturing a prototype of a component weighing several tons using the WAAM process. »



Photos (p. 16 and above right): Ramlab started 3D Printing its WAAMPeller back in 2017
Above left: Lieutenant Captain Sascha Hartig was also on the Formnext 2023 conference schedule to talk about the additive developments in the German Navy
At left: Among other uses, AM enables the German Navy to 3D-print defective parts while at sea. These components are then used until a ship reaches the next supply port where the original parts are available

Below:
How the WAAMPeller
is produced
At right:
A MaxQ WAAM repairing
a segment of a ship's
propeller



In the naval sector, Ramlab CEO Wegener sees the greatest potential for WAAM in the combination of high-quality parts and a significant reduction in lead times. »This is why you see the US Navy actively pursuing this technology for their submarines, for instance,« he points out.

CERTIFICATION REMAINS A CHALLENGE

According to Lieutenant Captain Hartig, the fact that Additive Manufacturing is not more widespread in naval applications is due to this being a rather conservative area of mechanical engineering. »Also, components in the metal sector are usually very large, and the development of the necessary machines has only taken place in recent years. The alloys used in shipbuilding are not, or at least have not been, the focus of the AM industry,« he explains. In addition, a major problem in this field is often that design data is the property of shipyards, and therefore not available. As a

further hurdle, Hartig mentions the necessary personnel expertise, including in design, printer operation, and post-processing. »This is very difficult to achieve with the resources available.« Nevertheless, Hartig's experiments with the German Navy have been successful »because we brought additional resources on board in the form of personnel and materials and thus did not restrict the crew.«

Meanwhile, Vincent Wegener believes that the biggest challenge in the further development of 3D Printing in the marine sector is the process of certifying printed parts. »Not only companies starting with WAAM need to go through a learning process to print parts and certify them; certifying bodies had and still have to go through this process, as well.« According to Wegener, knowledge of the process and acceptance of WAAM as an alternative manufacturing technology is steadily increasing. »After all, necessity tends to steer developments towards the desired outcomes.«

+ FURTHER INFORMATION:

- » ramlab.com
- » formnext.com/fonmag

Text: Thomas Masuch

SOMEWHERE BETWEEN PAINTINGS AND OBJ FILES

Having identified the technology as an excellent counterpart to traditional forms of art, the Hamburg-based artist duo Sutosuto is using 3D Printing in more and more of their projects. A selection of their works was on display in the AM Art Space at Formnext 2023.

LETTING IT BRAIN ON THE TRADE FAIR FLOOR

In cooperation with Formnext 2023, the artistic duo consisting of Susanne Dallmayr and Thomas Koch presented a series of works in the AM Art Space, a special showcase that drew attendees in droves over the course of this year's event. At the heart of the 63-square-meter showcase was a current Sutosuto exhibit dubbed »Let It Brain«, which comprises a great many 3D printed brains that light up in myriad colors. The space also included the self-consuming monster Hazfat and numerous large-scale paintings, one of which features faceless people in protective gear who are meandering through a sparse landscape with their heads in digital clouds. »The response to our booth was overwhelming. The best indicator was a comment we heard more than once: 'Your booth was the best! Keep it up!'« Dallmayr reports.

Over the more than 20 years in which they have been making art together, she and Koch have developed a striking artistic style rooted in painting and graffiti that now also includes large-scale sculptures – and 3D Printing. In other words, the two of them are not »just« designers, painters, and illustrators, but digital artists and sculptors, as well.

Dallmayr (now 37) and Koch (38) have known each other and been in a relationship since they were both students at htk Hamburg. After that, they started their careers in different fields – she as an illustrator, and he as an advertising agency.

Just inside the entrance, Captain Hamburg, the Rolling Stones, and German rock legend Udo Lindenberg stand ready to greet visitors. A bear that has made itself comfortable on an oversized currywurst awaits at the next corner, right next to a blue whale swimming through a tangle of straws and cocktail glasses. The studio of Sutosuto is home to a surreal world of characters both real and dreamed up, each of which has been put to canvas with a potent combination of creativity and skill.

The first time you wander down its main hallway, however, there's little indication that the place boasts more 3D Printing expertise than some industrial users of AM. It's not until you make your way through the maze of various workshops (which cover everything from painting to woodworking and grinding) that it gradually becomes clear: 3D Printing has not only well and truly arrived in this artistic haven in north-west Hamburg – it now plays an important role in Sutosuto's creative process.

Images: Sutosuto, Mesago/Mathias Kutt



Still, both carved out time for making art outside of work, which they initially devoted mainly to painting, drawing, and graffiti. The success they had led to Koch's decision to focus entirely on his craft, and Dallmayr followed suit some time later. »Our network has grown constantly, and we've continued to evolve artistically, as well,« Dallmayr reveals. »That's what enabled us to take part in exhibitions right from the beginning without any major promotional effort, and we also found people to buy our art.«



Photo (p. 19):
Susanne Dallmayr and
Thomas Koch in their studio
workshop in Hamburg ...
Photos (pp. 20, 21):
... and at the AM Art
Space showcase at
Formnext 2023

Meanwhile, the two were even able to create images four to five meters wide – for the cruise ship MS Europa 2, for example, or the bar of the Hamburg hotel 25hours. »That’s basically the dream of any creative person who’s focused on art,« Dallmayr points out.

FIRST FORAYS INTO 3D PRINTING

In 2015, it was a wall that needed decorating in that Hamburg bar that gave rise to the idea for a particularly affecting work of art: a peace sign made of intertwined hands, which was exhibited at Formnext 2022. At first, however, it was impossible to turn the concept into reality. »Our initial thought was to use plaster casts, but the weight and complexity involved in the project quickly made us realize that wasn’t going to work,« Dallmayr recalls. »We didn’t have any alternatives, so we filed the idea away for the time being.«

After finding themselves unable to get the peace sign out of their heads, she and Koch revisited it the very next year and contemplated other ways to make it happen. Both artists had been using 3D software for designs and models for some time, which made 3D Printing a relatively obvious possibility. They thus created an initial rough mockup in three dimensions and sent inquiries to a wide range of service providers. The responses Dallmayr and Koch received were not all that encouraging. »People either told us that the overall project was unprintable,

or impossible to calculate – or they quoted us a price over 250,000 euros, which was obviously a little outside of our budget,« Dallmayr explains.

THE LONG ROAD TO PEACE

With the artwork that would eventually be named simply Peace once again proving seemingly impossible to realize, Sutosuto opted to create a monster instead. The duo’s attempts to find a partner for creating their peace sign led to a cooperation with FKM Sintertechnik, a company based in Hesse. This in turn resulted in Hazfat, a self-consuming ogre of overconsumption standing 1.4 meters tall and weighing in at 210 kilograms, which was cast in bronze using a 3D printed mold. »We found the technology stunning and knew right away that we had to keep working with it,« Dallmayr says. »It wasn’t long before we’d assembled our own 3D Printing lab.«

After plying their trade on canvas during the day, the duo spent their evenings and nights researching printer technology, software, dimensions, materials, and more. The Sutosuto studio now features a 3D Printing workshop with a large-scale FFF printer, multiple stereolithographic printers, and even an upcycling loop, which consists of a shredder and filament maker that the duo says can turn household waste into fresh printing material. All these creative efforts don’t leave Dallmayr and Koch much time away from their creative space or computer screens,



of course. »After the past four years, I’d quite like to go on vacation for more than two days again,« Dallmayr admits. »We’re creators, though – even when we do get a little room to breathe, we just end up starting another new project!«

While the duo was exploring the possibilities of 3D Printing, they also made progress on Peace. Their first attempts at printing in their new workshop quickly made it clear that this creation would be best kept in-house. After spending another two and a half years on digital design, sculpting, and writing algorithms, Sutosuto succeeded in printing around 200 high-resolution hands in 2021.

This resulted in more than a hundred individual parts that were then glued together to form an impressive overall work measuring two meters to a side. The duo finished the surfaces of the hands to make it look as though they had been cast from plaster. At Formnext, even some 3D printer manufacturers were fairly stunned by the result. »Lots of people asked us whether it was really 3D printed; they couldn’t believe that such refined, detailed surfaces were possible with an object of this size,« says Koch, recalling the 2022 event.

FROM ARTISTS TO AM EXPERTS

Pulling this off required nothing less than pioneering work in applying 3D Printing to the world of art. Dallmayr and Koch spent day after

day reworking pieces, grinding surfaces, and reading up on things like machines and their technical idiosyncrasies, printer maintenance, component size, and the use of support structures. Their expertise in 3D Printing has grown so extensive that Koch has even been offered jobs as a technician or design engineer while attending Formnext.

It’s a fair question, actually: Is this still art, or more akin to engineering? »The technical aspect is also art – the art of engineering,« Koch insists. In the long term, the two artists want to explore even closer connections between 3D Printing and their other artistic production techniques. Their ideas thus far have included a combination of painting and 3D printed sculpture.

»GREAT COMPETITION FOR OLD FORMS OF ART«

These days, around half of SUTOSUTO’s works come from 3D printers. Dallmayr and Koch mainly use additive techniques in their free artistic efforts. These are projects that don’t pertain to any particular commission – Hazfat or Peace, for example – and enable Sutosuto to realize their philosophies without outside influence or the constraints of a specific concept. That said, »free« doesn’t come for free; the duo has to pay for the production costs themselves in these cases, which can run into the five figures. »This is important to how we see ourselves, but

it’s also an investment in our future as artists,« Koch points out. The self-image he and Dallmayr share contains aspects of sustainability, democratic renewal, and the battle of the good in humanity against dictators, oppression, digital oversaturation, and environmental pollution.

Meanwhile, the role 3D printed sculptures are playing in their commissioned work continues to grow. »For us, Additive Manufacturing is a chance to bypass conventional forms of production that are really energy-intensive – copper or bronze casting, for instance – and deliver a level of quality that doesn’t look like it’s 3D printed at first glance,« Koch explains, with Dallmayr adding: »3D Printing is great competition for old forms of art.«

Both are convinced that the work they have put in thus far has given them a technical edge in the art market. »Hardly anybody else is capable of realizing projects at this level,« says Dallmayr, who goes on to point out that 3D Printing is about much more than concepts and digital files. »The deciding factor is always the operator,« agrees Koch, who can now appreciate the challenges he and his partner faced in creating Peace and Hazfat. »We overcame pretty much every obstacle you can encounter in connection with 3D Printing. Anything we run into now probably won’t shock us anymore!«

+ FURTHER INFORMATION:

- » sutosuto.com
- » formnext.com/fonmag

OUTSIDE THE BOX



Grapes Worth Waiting For

Not long ago, I was waiting in the checkout line at the supermarket behind an unassuming fellow who looked like was well into his retirement years. »Do you have our app?« the friendly checkout clerk asked him. »No, and I don't plan to get it, either. You just want my data!« the elderly man snapped before launching into a tirade about how useless the digital world was.

This made me wonder what kind of critical information an app might gather on such a person, but at the same time, I could understand his point of view. Like the rest of his generation, he had managed to get by without apps for most of his life, and had perhaps even had more fulfilling years than some young whippersnappers do today. Maybe this type of nostalgia is also part of the reason why some digital developments are progressing at a snail's pace here in Germany.

»Oh, I don't think that's true,« replied the clerk, who remained astoundingly good-natured and professional. »Our company is only interested in how you shop.« Soon enough, it was

my turn, and I pulled out my phone to have my app scanned. I'm happy to share information about my shopping habits; I like getting good deals on avocados now and then, and I'm interested in finding out what a supermarket's AI thinks of a person who mostly buys fruit, vegetables, milk, and butter.

However, the app has now started to send me coupons for bacon and meat salad from nearby regions that I don't usually visit. Can you really call that intelligent customer analysis? Or did they just make way too much meat salad? I could always ask the checkout clerk next time ...

My wife, who's much savvier when it comes to the digital world of shopping, recently set up an account with the delivery service of another supermarket chain. That makes her part of a very small minority in Germany, where just 2.9 percent of people bought their groceries online in 2022.

While we haven't actually received any food yet, we did get number 973 on the waiting list. At first, I thought this was a clever market-

ing ploy: Limited availability does make something seem more valuable, after all. It's like with every release of a new Apple product, when eager fans start lining up outside the stores in the early hours of the morning. Instead of the latest iPhone, however, we're talking about onions and broccoli.

Four weeks after registering, my wife had climbed all the way up to number 970. The delivery service's app presented her with coupons for grapes and a jar of strawberry jam – to »make the wait a little sweeter«, it said. If things keep moving so quickly, we'll be thrilled to get those delicacies at a discount in just 323 months, which isn't even 27 years. And who knows? Maybe we'll get a few more coupons in the meantime – for meat salad, if we're lucky! If not, I'll be the retiree waiting in line at the supermarket, just waiting to tell the friendly checkout robot that I've had enough of the digital world.

Text: Thomas Masuch

Illustration: feedbackmedia.de, iStock / jemastock

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

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