Formnext 2021: Successful Relaunch as a Face-to-Face Show

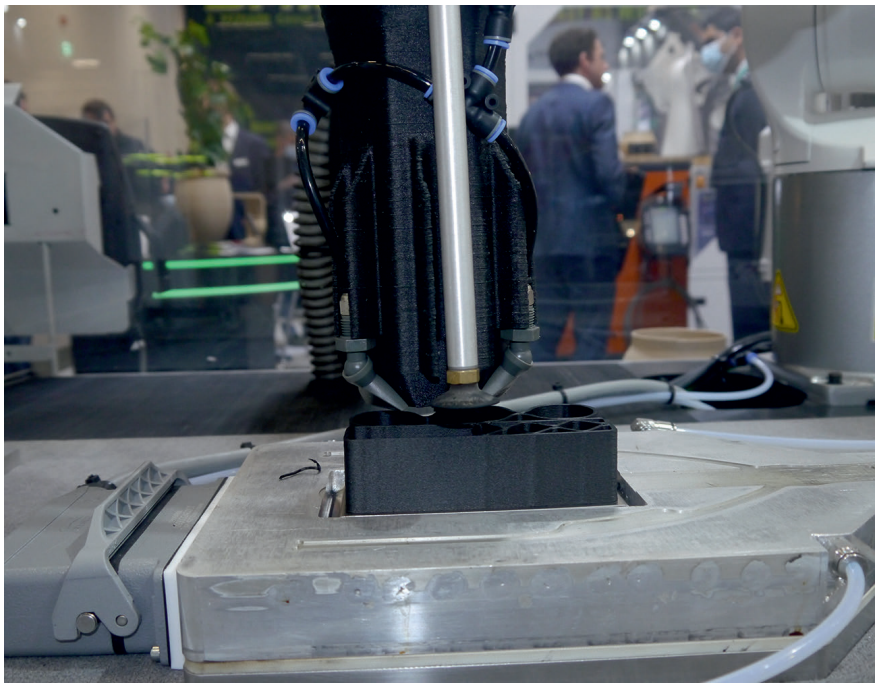
High-Performance 3D Printing

Over the four trade-show days in November, Formnext 2021 transformed the metropolis of Frankfurt am Main, Germany, into an international innovation center of global additive manufacturing and modern industrial production. At the plastics side, some of the focuses were on the manufacture of voluminous parts, the use of injection molding pellets as a material basis, and the processing of high-performance plastics.

The organizers counted over 600 exhibitors from 36 countries and almost 18,000 visitors, about half of them from abroad. You did not have to look far to become aware of what was probably the biggest product campaign among machine manufacturers. Peter Alderath, General Manager DACH at Stratasys, in a conversation with ***Kunststoffe***, summarized the renewed portfolio as follows: "Since last year, we have supplemented our tried-and-tested PolyJet and FDM technologies with three more, which we lacked until now: stereolithography, DLP and SAF."

In detail, since taking over the start-up Origin about a year ago, Stratasys has also had a foothold in the fast growing segment of mass production of parts with a photopolymer platform. Origin's so-called P3 technology – it stands for "programmable photopolymerization" technology and is an evolution of digital light processing (DLP) – uses light to cure liquid photopolymers. With the 3D printer Origin One, according to Alderath, users can achieve the quality of injection molding and their surface finish with high accuracy and a large number of high-performance materials. Only a little later, Stratasys took over RP Support (RPS) of the UK in order to add the Neo system line to its portfolio, which comprises three models in two sizes.

In April 2021, Stratasys had already presented the H350 3D printer, the first system that works with selective absorption fusion (SAF) technology, a powder-bed fusion process developed by Xaar 3D. Here, the polymer powder particles are wetted with an infrared-sensitive fluid and then irradiated to fuse them together in discrete layers. The H350 even incorporates a dozen components that were 3D printed by the SAF process. Now, Stratasys has also taken over Xaar 3D.



A high-strength carbon fiber-reinforced polyamide is printed on a plasma-treated stainless steel sheet. © Hanser / C. Doriat

But there are innovations in other areas, too: the F770 FDM printer is especially suitable for large components; according to the manufacturer it has the longest fully heated build chamber available on the market, and a generous build volume of almost 0.4 cubic meters. And with multimaterial 3D printers such as the J35 Pro and J55 Prime, product designers can manufacture ultrarealistic prototypes, for example of packaging, in a single printing operation using the PolyJet process (**Fig. 1**).

Expanded Material Spectrum: PEEK for Medical Technology

Arburg is using PEEK (polyether ether ketone), which is particularly suitable for medical purposes, to further extend the applications scope of Arburg Plastic Freeforming (APF). At Formnext, a Freeformer 300–3X designed for high-temperature applications processed, for the first time, the plastics pellet stock "Vestakeep i2 G" from Evonik to produce skull-implants (**Fig. 2**). "The fact that it is a medically approved original plastic pellet material for permanently implantable medical products is exciting interest within the additive manufacturing sector. In addition, this material is also interest-

Fig. 1. PolyJet printing allows designers to create full-color packaging with integrated graphics and labels in one step. © Stratasys

ing for technical parts," says Martin Neff, AKF department manager at Arburg.

The machine is specially equipped for processing high-temperature plastics: the build chamber can be heated to 200 °C, and optimized temperature management ensures the necessary cooling of the system, in particular the axis drives, which position the part carrier highly precisely with 0.022 mm accuracy in the x, y and z directions. The Freeformer is also predestined for practical use in medical technology, because "the process quality can be reliably documented and each component can be clearly tracked," says Neff. With the "ProcessLog" app developed especially for the Freeformer, available via the customer portal "arburgX world," various process and build job data can be clearly represented in graphical form for all parts. To demonstrate this at the trade show, each part received a label with QR code. The QR code can not only be used in the ProcessLog to inspect details of the machine, the materials to be used and job start and end, but also the recorded process data throughout the entire build time, with detailed information about melt pressure, screw position, drop frequency and volume output.

In this context, the "MachineCenter" app is also useful. It provides a clear overview of all the customer's Freeformers. For each machine, documents can be called up, for example on material profiles, software packages, sample parts and materials data sheets. Operating and maintenance manuals, as well as installation plans are also stored here. To allow use of these functions – as well as of the newly available remote service, in which Arburg hotline support staff, by agreement with the customer, connect directly to the machine control system via a secure and encrypted data connection – all the new Freeformers are equipped with an IIoT gateway.

Another medtech application was demonstrated as part of a joint project with the University Clinic of Basel, Switzerland, using a Freeformer 200–3X. The set-up exhibited in Frankfurt manufactured resorbable implants from a composite of poly(L-lactide-co-D,L-lactide) and tricalcium phosphate (β-TCP). The material (type: Resomer LR 706, also from Evonik) contains 30 % ceramic additives – this makes the implant strong and also releases calcium to promote bone growth.

Even materials that have not been accessible by additive manufacturing before can be processed by the AKF process, as was demonstrated by Arburg with the example of a part of semicrystalline PBT. The material is flame retardant with a high dielectric strength and is suitable for electronics housings. In a joint process with Balluff and the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA), a Freeformer produced individualized sensors. A housing was additively manufactured from PBT and the process interrupted from time to time in order to manually insert the coil, circuit board and plug, and to create conductor paths.

As was demonstrated by tesa, plastic freeforming can also be applied to unusual materials. The brand-name manufacturer renowned for its self-adhesive system solutions developed its own adhesive granules for particularly sustainable solutions. Thus, smartphone components can be bonded with almost zero-waste by means of self-adhesive strips, just a few layers thick, applied in the Freeformer. This compares with traditional stamped adhesive materials, in which 90 % of the starting material must be disposed of as scrap.

LSR Components

A pioneer of liquid additive manufacturing (LAM), innovatiQ, recently became part of Arburg's subsidiary Arburgadditive GmbH + Co KG. With the aid of this process, highly elastic components, such as gasket rings can be economically printed individually and in quantities as low as 1. In a live demonstration, the industrial printer LiQ 320 manufactured components such as hand protectors or shoe soles from liquid silicone rubber (LSR). With the newly designed LiQ 7, innovatiQ also unveiled a solution for the series production of colored LSR components. Color dosage can also be controlled in detail, and thereby a wide spectrum of colors achieved.

Independent Dual Extrusion System

For first time in Europe, the US company Essentium presented its HSE 280i HT 3D printer, the first genuine independent dual extrusion system (Idex, Independent Dual Extruder), which was developed for the requirements in industrial production. Dr. Blake Teipel, CEO of Essentium, stated that "Whereas most Idex systems have print heads that are independent in the X-axis but connected to one another in the Y-axis, the Essentium HSE 280i HT is completely independent in both axes. Users can employ five print modes: single head mode, support mode, multi-process mode, copy mode and independent mode. "The build volume in multi-process mode is 595 x 495 x 600 mm; the throughput – HSE stands for high- »

Fig. 2. Skull implants of PEEK. The support structures behind it are so loosely designed, they can be mechanically detached. © Hanser / C. Doriat

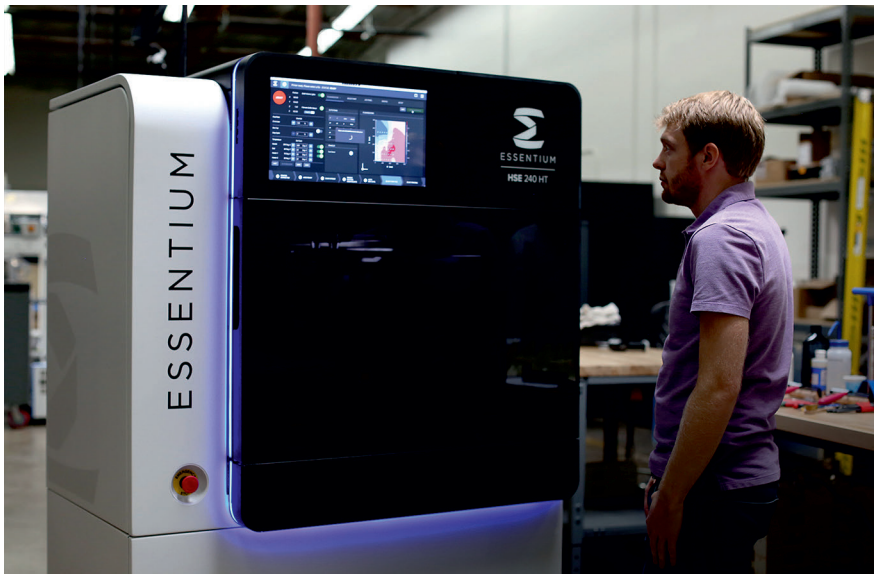


Fig. 3. The HSE 240 HT Dual Extruder is a 3D printing platform with dual extrusion die head.
© Essentium

speed extrusion – is up to 200 g/h. The machine is suitable for functional prototyping and series production with technical high-performance filaments.

With the HSE 240 HT Dual Extruder, Essentium has also designed a 3D print platform with dual extrusion print head for small and medium-sized production facilities and university laboratories (**Fig. 3**). It features three print modes (single head/support/multi-process), which allow parts to be produced from different materials in one print operation. With a build volume of 430 x 350 x 375 mm, 3D printers offer performance characteristic such as 3D high-speed printing, automatic spool switching for long print jobs and an internal camera for remote monitoring. In addition, it has a build chamber that can reach temperatures up to 185 °C and a heated nozzle that can reach up to 550 °C in order to ensure the mechanical strength of the production parts.

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3D Pellet Printer with High Build Rates

AIM3D GmbH is a startup founded in 2017 as a spin-off of the University of Rostock, Germany. The company manufactures industrial 3D printers working by the CEM (composite extrusion modeling) process. It allows the manufacture of parts from reinforced thermoplastics, metal and ceramics based on commercially available injection molding pellets without retrofitting work on a multimaterial 3D printing system. In the two last-mentioned cases, in the pellet stocks known from metal or ceramic injection molding (MIM/CIM), only the plastic component (binder) is melted to generate a green compact. As unique selling point, the 3D printers have a patented CEM extruder that can process almost any injection molding pellet stock up to a diameter of 3 mm (**Fig. 4**).

Now, with the ExAM 510, AIM3D has presented a 3D printer for larger build volumes, higher precision and build rates. The new multimaterial printer is an enhancement of the smaller ExAM 255 version, and can process up to three materials in parallel – two build materials and a support material. The significantly increased build rate is up to 250 cm^3/h, depending on the material (if a 0.4 mm nozzle is used). According to Clemens Lieberwirth, CTO at AIM3D: "This extruder class allows an extrusion rate that is higher by a factor of up to 10 than a commercial filament extruder. Due to the use of linear motors and a stable mineral cast bed, it is possible to work with high precision even at high speeds, and thereby tap the potential of the technology."

The enlarged build chamber of 510 x 510 x 400 mm can be temperature controlled up to 200 °C in order to reduce stresses in the part. The heated process chamber also allows high-performance plastics such as PEEK, PEI, PSU or PPS, with and without fiber reinforcement, to be processed as pellet. This means a huge cost advantage for raw materials. With the example of PEEK, the high economic efficiency can be seen most clearly: with a PEEK filament price of approx. EUR 700/kg on conventional AM systems, the ExAM 510 can use PEEK pellet, whose market price of about EUR 50 kg represents a costs factor of about 14.

The traditional fields of applications for these materials can be found in the automotive industry, medtech or aerospace, where AIM3D's pilot customers are also based. After a beta phase with pilot processors, the ExAM 510 should be ready for series production by Formnext 2022, according to the manufacturer.

Connection between Incompatible Materials

Another tried-and-tested solution for the additive manufacturing of high-load-bearing large-volume parts is the SEAM process. "Screw extrusion additive manufacturing" is characterized first by the use of standard pellet and on the other hand by high throughputs of more than 5 kg/h. At Formnext, Yizumi again pres-

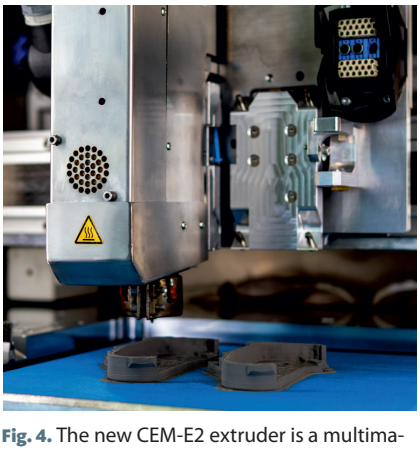

Fig. 4. The new CEM-E2 extruder is a multimaterial print head, which can print the materials metal, plastics and ceramic. © AIM3D

ented an application that – although of small dimensions – had already been shown at Fakuma: the processing of high-strength polyamide based on castor oil, which is reinforced with 40 % recycled carbon fibers (PIR), on a stainless steel sheet (**Title figure**). A firm bond between these normally incompatible materials is created by depositing a wafer-thin film of adhesion promoter on the sheet using plasma treatment before the start of the print job.

"The throughputs and material properties that can be achieved with the SEAM process, combined with a component-appropriate design, make it possible to achieve quantities of over 10,000 by additive manufacturing, and offer an alternative to injection molding," explained Dr. Nicolai Lammert, head of the Additive Manufacturing business unit at Yizumi Deutschland. "Scaling via the number of systems or, within a manufacturing cell, via the number of extruders and dies multiplies the production rate at low investment costs."

A genuine example of "large format additive manufacturing" (LFAM) was presented by the Italian manufacturer CMS (Costruzioni Macchine Speciali) with the manufacture of a part over one meter long. This, together with the hybrid manufacturing system Kreator, which was developed together with the Fraunhofer Institute and took up roughly the space of a garage at the tradeshow booth, combined a SEAM unit (up to 7 kg/h output) with a 5-axis milling machine for secondary finishing.

By the way, with Italy, a European partner country was presenting itself at Formnext for the first time. One of the many exhibitors from there, with a notable new development in its suitcase was Roboze. The company presented a

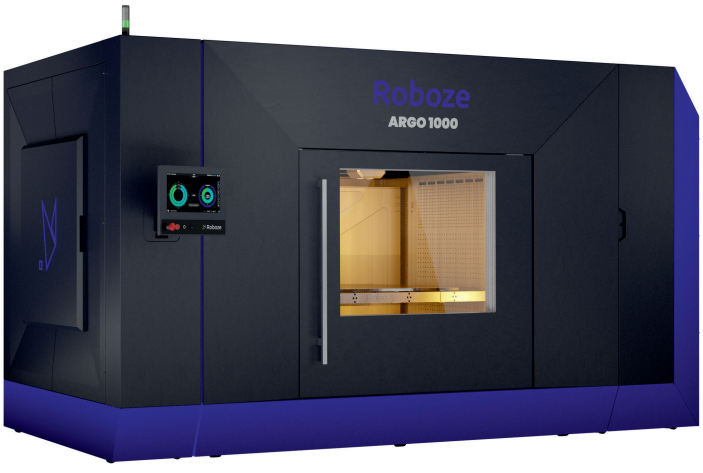

Fig. 5. The Argo 1000 is the biggest machine with a heated process chamber for additive processing of reinforced materials and high-performance plastics. © Roboze

machine, which is claimed to be the biggest one available, with a heated process chamber for additive processing of composite materials and high-performance plastics, such as PEEK. The new model Argo 1000 has a build chamber of one cubic meter (1000 x 1000 x 1000 mm) and a patented dryer integrated in the machine bed (**Fig. 5**). The high performance control system from B&R and the beltless technology, also patented, from Roboze increase the printing rate and effect six times higher repeatability than belt-driven printers. The printing technology is reminiscent of the kinematics of industrial machine tools.

Pioneer of Metal Substitution

The high mechanical properties and the dimensional tolerance of the manufactured parts are the result of precise temperature management during the entire process. The material is extruded at up to 450 °C, while a homogeneous temperature of 180 °C prevails in the entire process chamber. This is achieved by means of a constant heat flux, generated by a collector, which is mounted on the underside of the build structure, sucks in the introduced air and, after heating it, guides it back into the chamber through the holes in the side walls.

The fully networked machine based on the B&R control system ("Roboze Automate"), with its sensors and remote control and diagnosis functions, simplifies the entire workflow and the generation of reports from all phases of the printing process. The digitalization also permits predictive maintenance and constant automatic updating of new functions and software parameters. "The Argo 1000 will be a pioneer in metal-replacement applications in challenging industries, such as aerospace, as well as the mobility and energy sectors," said Alessio Lorusso, founder and CEO of Roboze. Market launch is planned for the third quarter of 2022 – in time for the next Formnext. This year, the trade show takes place from November 15 to 18. ■

Dr. Clemens Doriat, editor