AMPOWER INSIGHTS

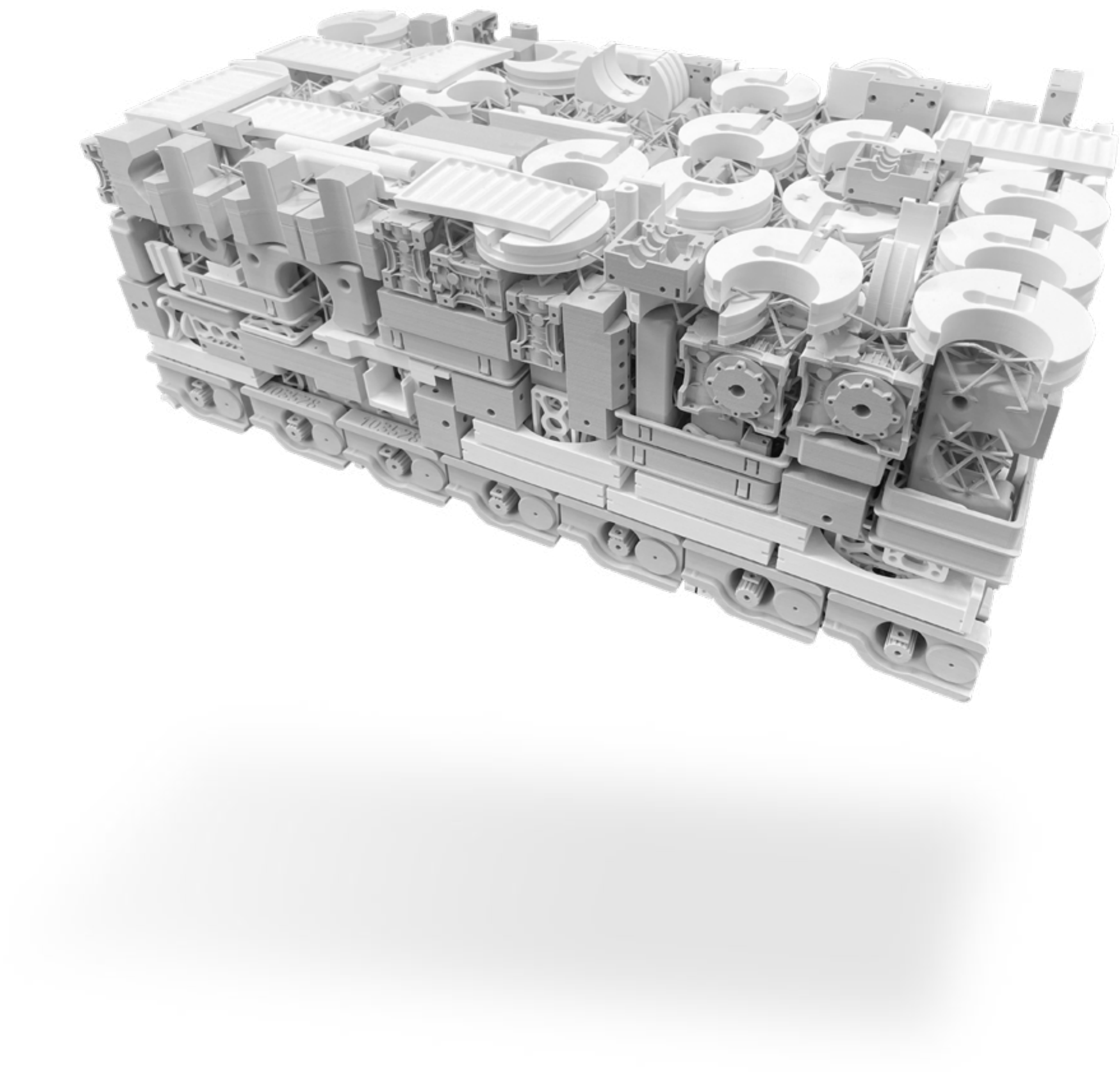
Additive Manufacturing
New polymer technologies

Upcoming technology principles:
Potential and outlook

INSIGHTS GAINED:

- Overview of upcoming polymer AM technologies
- Potential, opportunity and availability
- Maturity assessment

Vol. 11
November 2022



COURTESY OF INKBIT

Insights gained

Overview of upcoming polymer AM technologies
Potential, opportunity and availability
Maturity assessment

Management summary

Polymer Additive Manufacturing is often associated with Material Extrusion, Laser Powder Bed Fusion or Photopolymerization technologies. However, there are 17 different technology principles identified today. While some of these principles are in an early development stage, many are successfully used in industrial set-ups or are expected to find a viable niche as manufacturing technology.

To be successful in using polymer Additive Manufacturing, it is crucial to choose the right manufacturing technology, established or new. The 11th volume of AMPOWER Insights provides an overview on upcoming technology principles and assesses their potential.

To evaluate the state of the art of polymer Additive Manufacturing, AMPOWER has developed a methodology - the AM Maturity Index. This index provides the user with a tool for quick assessment based on the technology as well as industrialization maturity. While the technology index evaluates the current production process capability and machine concept, the industrialization index reflects the existing knowledge base and availability in the market.

The reviewed technologies are clustered into different groups. The first group are volumetric technologies from vendors such as XOLO and READILY. The second group covers high viscosity photopolymer technologies which were announced by BCN3D and CUBICURE in 2021 and 2022, respectively. Both technologies utilize high viscosity photopolymers to enhance material properties combined with a high throughput approach.

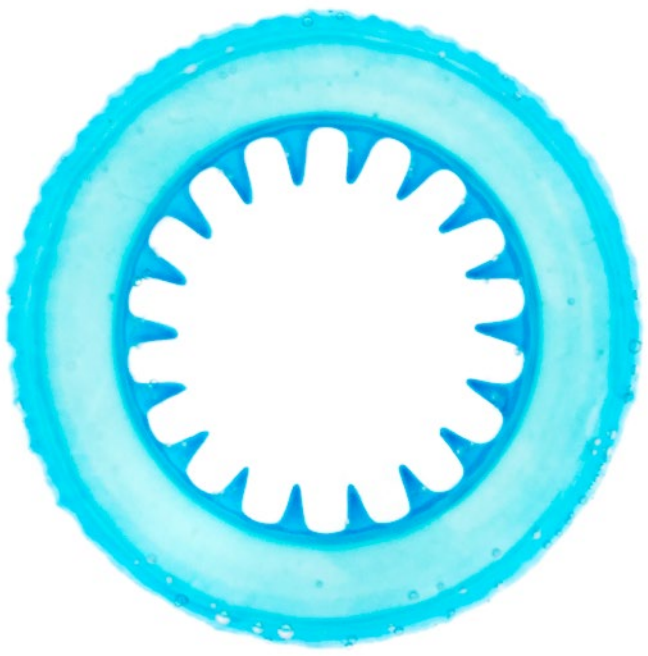
The third group comprises powder technologies. Included are EVOLVE with its Electrophotography Lamination Process and IMPOSSIBLE OBJECTS.

With 3DEUS DYNAMICS and SPECTROPLAST there is another group of elastomer technologies able to process silicone material for consumer goods as well as medical applications.

Last but not least new thermoset technologies are commercialized by MASSIVIT and INKBIT. MASSIVIT large-scale printer aims at decreasing lead time in mold production. INKTBIT combines Material Jetting with process control and new material developments to push its use in production environment.

Today, AMPOWER rates these aforementioned technologies at a relatively low industrialization and technology maturity level. However, the high potential may yield a fast shift, if industry adoption can be achieved.

Download this paper at www.ampower.eu/insights



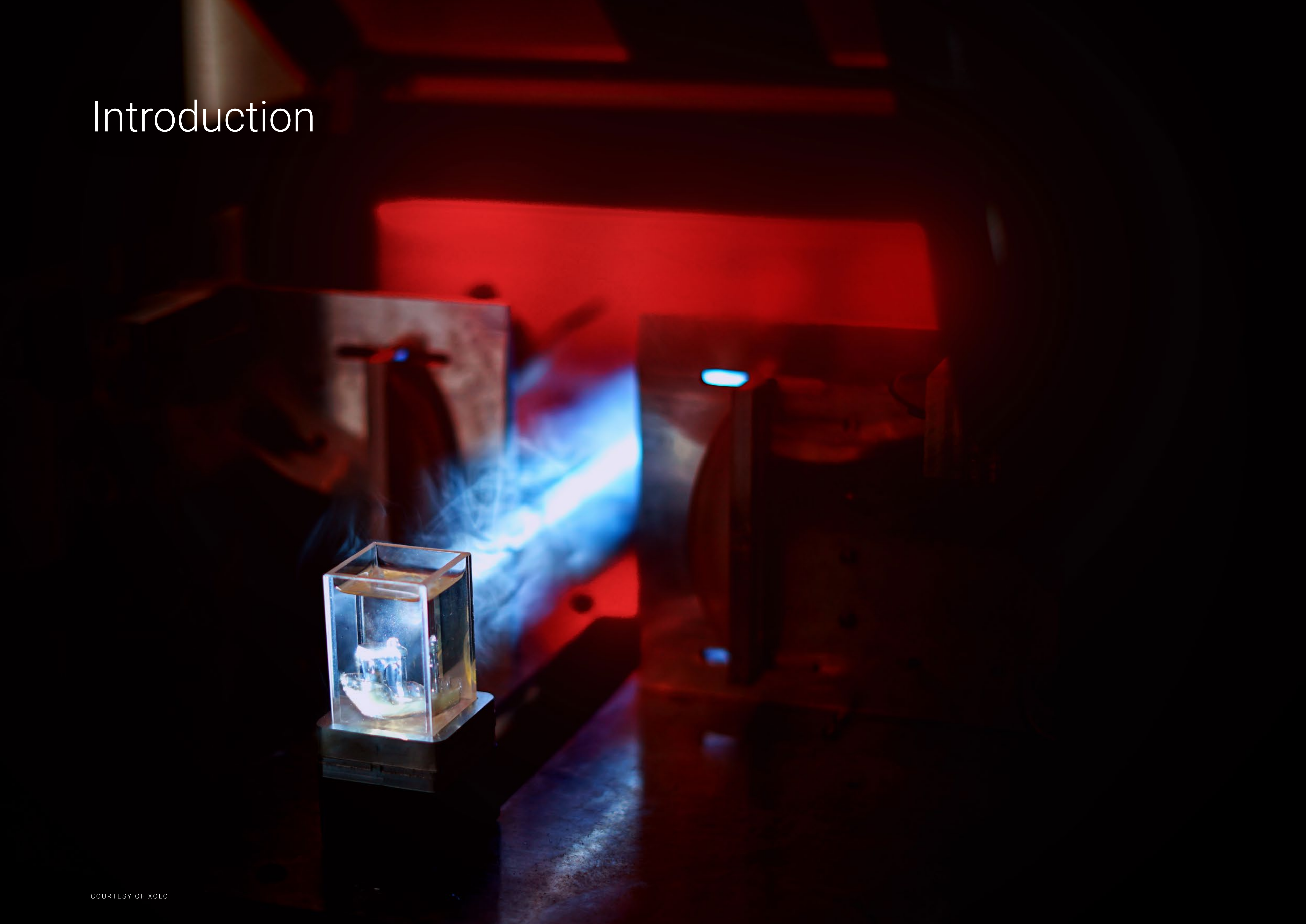
COURTESY OF READILY3D

About AMPOWER

AMPOWER is the leading consultancy in the field of industrial Additive Manufacturing. AMPOWER advises their clients on strategic decisions by developing and analyzing market scenarios as well as compiling technology studies. On operational level, AMPOWER supports the introduction of Additive Manufacturing through targeted training program as well as identification and development of components suitable for production. Further services include the setup of quality management and support in qualification of internal and external machine capacity. The company is based in Hamburg, Germany.

Content

Introduction



COURTESY OF XOLO

Polymer Additive Manufacturing landscape

Polymer Additive Manufacturing is often associated with Material Extrusion, Laser Powder Bed Fusion or Vat Polymerization, however there are in total 17 technology principles being used in industry today.

AMPOWER clusters the different polymer AM technologies into two groups. Solid thermoplastic technologies and resin based liquid technologies including thermoset and elastomer materials.

Thermoplastic AM technologies create the part by melting filament, pellet or powder. During cooling the molten material solidifies and creates the final geometry of the part.

The other group are resin based, which can be subdivided by the used polymer:
thermosets or elastomers. Vat Polymerization is one of the most used liquid AM technology consuming thermoset materials such as acrylates as feedstock. The feedstock is cured by an energy source that initiates the crosslinking between polymer molecules. This chemical process leads to solidification and the generation of each layer. The solidified material is usually neither reusable nor recyclable and the liquids often have a limited shelf life. Within Polymer AM, several technologies are used across multiple industries for prototyping. In some applications Polymer AM has reached a high volume serial production status. A prime example are resin technologies that produce dental aligner molds in the millions or lattice components for shoe soles in the hundred thousands. Still, these are only few business cases that were successfully commercialized by pioneering industrial users, which have developed the entire process chain to deliver the needed properties.

Material Extrusion, on the other hand, is used mostly in small series or for tools and fixtures. While this process seems to be the least scalable, it has the widest material range to offer and is used in multiple industries with high impact, such as to shorten lead times.

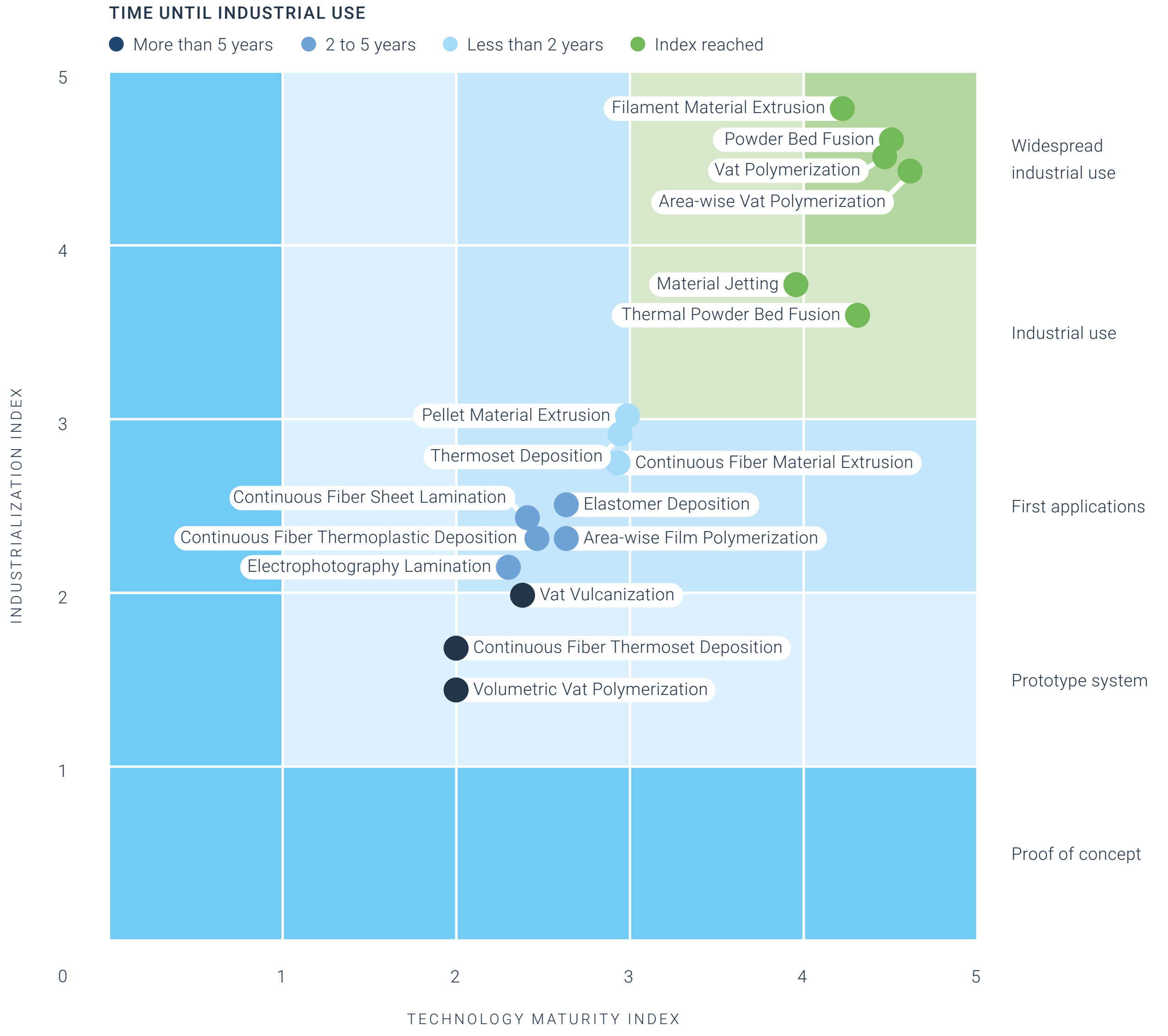
Assessment of state of the art of Polymer AM technologies

Many polymer AM technologies reached the AMPOWER Maturity Index over the past years. Especially Powder Bed Fusion and Polymerization technologies are widely used for specific products across multiple industries. However, multiple technologies are still just arising from the diverse technology landscape.

To evaluate the different AM technologies AMPOWER has developed a model to describe the technology readiness level of an Additive Manufacturing technology based on two indices. The Industrialization Maturity Index and the Technology Maturity Index describe and compare the capabilities and adoption rate of each AM technology in an industrial environment. Both indices are crucial factors for evaluating the current status of a technology.
Within Polymer AM several technologies reached the index for their daily use in multiple industries. Powder Bed Fusion is one of these technologies. First used as a prototyping technology, it is used for serial production for more than a decade. Several applications were successfully commercialized, and multiple industries use the potential to produce parts in low to mid size volumes mostly with nylon materials. Other technologies like Area wise Vat Polymerization entered the market much later but progressed fast due to new materials and highly increased production speeds. This led to unlocking of completely new applications. One example are lattice structures, used to manufacture shoe soles and pads to enhance comfort.

Additionally, to the established technologies, there are many technologies on the edge to industrialization as of today. These AM technologies are employed mostly in the prototyping or in the application development phase. AMPOWER sees a potential for several of the new technologies to create value for certain industries. However, they still need to prove their capabilities in an industrial environment.

Maturity Index 2022 for Additive Manufacturing



Industrialization Maturity Index

Technology Source:
Proprietary technology with high IP barrier to multi source technology

Installed Base:
Only installed in research facilities to installed base in various industries

Knowledge Base:
No general knowledge available to high knowledge base with dedicated research programs

Material Availability:
Proprietary raw materials to multi source and large choice of materials

Experience and Applications:
Application development to serial production in multiple industries

Standards and Best Practice:
No standards available to established standards and best practices across industries

Technology Maturity Index

Series production capability:
Basic R&D on manufacturing use to established in full scale series production with integrated periphery

Process capability:
Basic process R&D to defect free, high repeatability and reproducibility for any parts

Machine concept:
Proof of concept and prototypes to off the shelf series and customizable machines

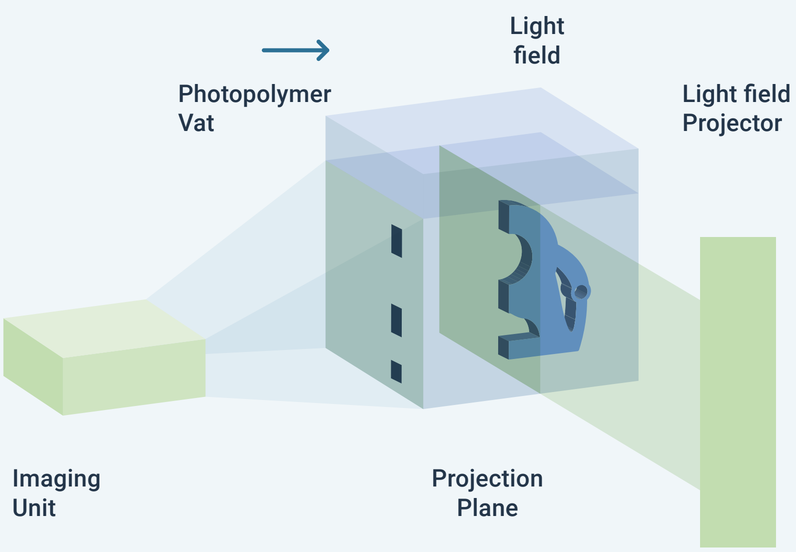
Process Control:
No features to in process control and simulation

Volumetric technologies

COURTESY OF XOLO

Volumetric Vat Polymerization by XOLO

XOLO, a Berlin based company, is the inventor of a Volumetric Vat Polymerization approach. The name of the company itself describes the technology: The crossing (X) of light and a perpendicular projected hologram initiate the curing of the layers within a vat.



Two light sources, which are positioned in a 90-degree angle, project light into vat filled with photopolymer resin. One of the projectors applies a light field with wavelength λ1 to excite a thin layer of photoinitiator molecules from dormant state into latent state. The second projector emits wavelength λ2 and projects the desired geometry layer by layer. Only the double irradiated molecules solidify and hence form the final geometry. The current set up features a projector with 3840 x 2160 pixels resulting in a pixel size of 21 x 21 µm.
Unlike other Polymerization technologies this process does not require support structures, due to the resin's high viscosity.

The combination of two light sources and the continuous approach of the technology alsoresults in a short process time. This means that components can be produced in the build volume in just a few minutes. However, it should be noted that the build volume (50 x 50 x 50 mm³) is currently still comparatively small, and scaling of the build volume is limited, mainly caused by the limited light penetration through the resin.

Potential

High speed and no support structures

- **High speed**
  In a build volume of 50 x 50 x 50 mm³, a printing time of only 1-2 minutes is needed
- **No support structures**
  The surrounding resin "holds" the part and is used to support the part geometry
- **Reusable material**
  Material that isn't solidified, can be used for the next manufacturing cycle

Technology Maturity Index

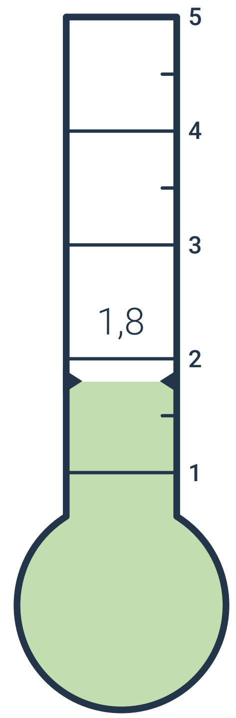
Fast and detailed technology for small transparent components

2 **Series production capability:**
Printing prototypes in a short time.
No series production.

2 **Process capability:**
Process is limited to small size parts.
Material is proprietary.

1 **Machine concept:**
No serial machines available.
Current systems mostly in R&D.

1 **In-process quality control:**
Basic machine with no dedicated process control



Interview with XOLO

What was the initial idea to look into the technology?

We were three founders with very different backgrounds. One of those is Prof. Stefan Hecht. He is an expert in photoswitches and photochemistry. We were searching for application of this expert knowledge and came across a scientific paper proposing a new volumetric display. The combination of the technical display set-up idea and Stefan's expertise to design photoswitches led us to a new form of volumetric 3D printing: XOLOGRAPHY.

When and what was the situation where you realized this is something we can go to market with?

We were new to the world of 3D printing and had to do our homework in researching the industry. We saw the weaknesses of state-of-the-art methods: they all use layers, and those layers are effectively glued together. Printing in the volume addresses this problem directly.

Can you summarize the unique selling point of your technology?

XOLOGRAPHY is super-fast, allows for total design freedom with no support structures, creates smooth surfaces up to optical grade and works at the other end of the material spectrum compared to SLA/DLP (high viscous resins with no additives and very little photoinitiator involved).

What other AM or traditional manufacturing technologies do you see as competition to your technology?

XOLOGRAPHY is light based printing and therefore closely related to stereolithography, digital light printing, CLIP and 2PP. But also, to usual lithography processes.

Where do you see boundaries or limitations?

There is a clear limitation in terms of build room. (Light-)energy has to be distributed throughout a vat filled with a resin. The larger the vat the harder it gets to introduce enough energy to every voxel within the vat due to the Lambert-Beer law. Resins also need to be transparent for those wavelengths used to initiate polymerization.

Dirk Radzinski

CEO & Co Founder at XOLO

Cofounded several deep science companies
Previously tech transfer pioneer at Humboldt University
Studied law and economics

COURTESY OF XOLO

Fast facts on XOLO

Founding of company: 2019
Investors: Paua Ventures, 20 Business Angels
First material: UDMA, Gelma
First industry: Likely bio printing
First application: Super high resolution scaffolds for bio printing
Commercial availability: 2023

What has been the most challenging hurdle to overcome, the most challenging development?

The technology is very new, and it is very different. However, it competes to a certain extent with existing technology which has been iterated for more than 20 years and where many smart and intelligent people push it to the next level. Volumetric printing must leapfrog those technologies in certain industry verticals, though only a fraction of talent is working on the challenges of volumetric printing compared to legacy technologies.

In 5 years, what is your vision regarding this technology?

The goal is to establish XOLOGRAPHY as a synonym for volumetric printing and advance volumetric printing to a level where large communities formed around use cases. Those communities entered markets which are not addressed by conventional 3D printing methods. In fact, new markets will evolve because of volumetric printing.

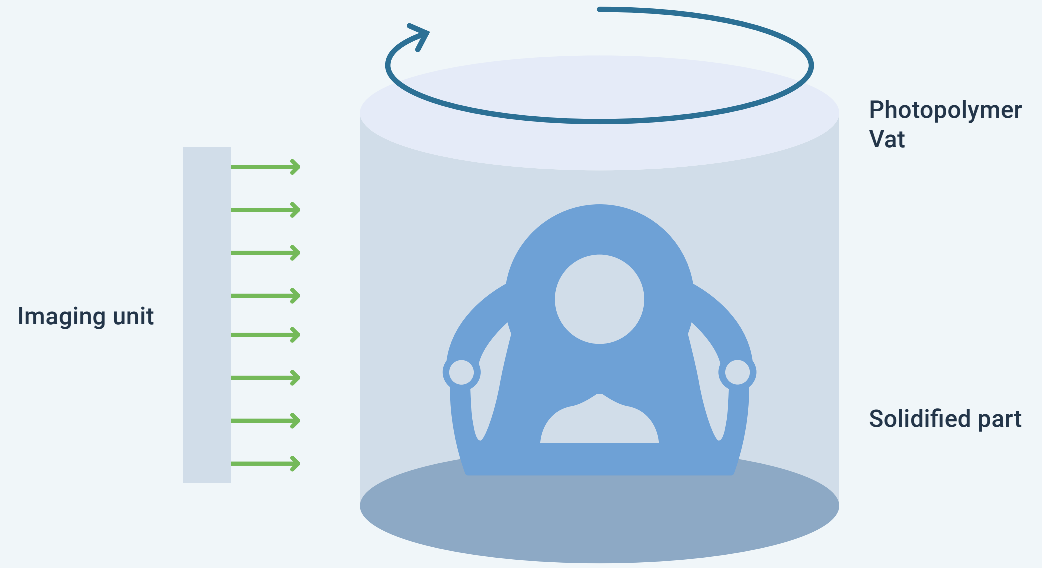
In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

We are in the early phase of the development. But we envision to reuse our un-cured materials. Since we can address every single voxel in the build room, we can also fill the vat which contains the liquid resin in all dimensions with as many models as desired leaving very little waste.

COURTESY OF XOLO

Volumetric Vat Polymerization by READILY3D

The Swiss-based company READILY3D (founded in 2020) invented this Volumetric Vat Polymerization process also known as Tomographic 3D Printing. It uses the same mathematical procedure as computer tomography but in reverse.



Computer tomography uses x-ray technology to take images from 0° to 360°. Multiple two-dimensional pictures are assembled to a three-dimensional model by using the Radon-transformation, a mathematical theorem, related to the Fourier-transformation.
TOMOGRAPHIC 3D PRINTING also uses this theorem but to separate an object into many cross-sectional layer images. A system of lasers and lenses projects between 100 and 300 images per second into a photopolymer, which rotates in a vat by 60 degrees per second. Depending on the used resin, the desired contours are polymerized within 30 to 120 seconds.
Today's process uses a build diameter of 5 to 20 mm and a maximum height of 27 mm. TOMOGRAPHIC 3D PRINTING is a sterile process since the printer does not come in contact with the material, which is contained in a transparent sealed container. This feature enables the printing of human cells in addition to polymers. A target market for READILY3D is hence the medical sector.

Potential

Sterile production process for polymers and bioprintable materials

- **High speed**
  For a build diameter from 5 to 20 mm and maximum height of 27 mm, the printer needs about 30 to 120 seconds
- **No support structures**
  The rest of the resin holds the part and is used as a flexible mold
- **Sterile Process for medical goods**
  Material is in a sealed container with no contact to the printer itself

Technology Maturity Index

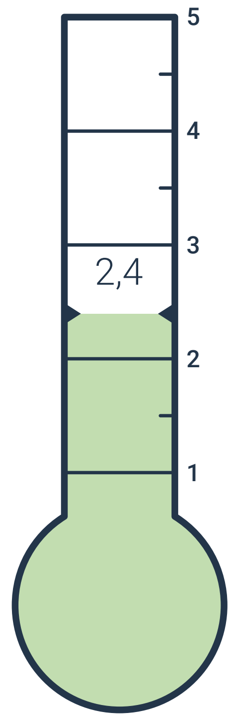
Technology at advanced state of its development

2 **Series production capability:**
R&D on manufacturing use and application development.

3 **Process capability:**
Printing applications for medication testing.
Other applications in development.

2 **Machine concept:**
First machines sold to research institutions and companies.

3 **In-process quality control:**
Cameras control the production process.



Interview with READILY3D

What was the initial idea to look into the technology?

During my PhD at EPFL, I worked on light-shaping algorithms for optical imaging, and my colleague Paul Delrot worked on microscale additive manufacturing using holography. Quite soon, we discussed the possibility of using tomography for additive manufacturing. Each of us still needed to wrap up our PhD research, but we found time to test this experimentally in 2017. When we saw that it worked from the first try, we realized we were onto something.

When and what was the situation where you realized this is something we can go to market with?

Over time, we increased the range of printable materials and the achievable resolution, and we published our results. Several companies and researchers heard of us and reached out to know if they could have access to the technology. We realized that the exclusive capabilities of this process could make a difference in many applications and decided it was time to build the first standalone prototypes and sell them.

Can you summarize the unique selling point of your technology?

It's extremely rapid, with print times of the order of 30s to 1 min for centimeter-scale objects. Additionally, the resin and the printer are never in direct contact, which helps to maintain a sterile environment in biomedical applications and eases cleaning. And third, objects are supported by the resin during printing, so no temporary struts are needed. This reduces manual labor post-print.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

There are many different processes out there, each with their pros and cons. It is difficult to compare them without regard for the application. In bioprinting for example, no other technology comes close to tomographic printing in terms of speed and cellular viability.

Damien Lotterie

CEO & Co founder of READILY3D

Degree in electrical engineering and PhD in optics at Ecole Polytechnique fédérale de Lausanne.
Manages sales, financing and software development at Readily3D

Fast facts on Fast facts on Readily3D

Founding of company: 2020
Investors: PBusiness Angels
First material: First material: Hydrogel
First industry: First industry: Life Sciences
First application: First application: Bioprinting
Availability: April 2021

COURTESY OF READILY3D

Where do you see boundaries or limitations?

It's a 3D printing process for clear (or translucent) resins and objects up to approximately 100 mm in size. The size boundaries is, however, likely to be pushed further as more efficient materials are developed.

What has been the most challenging hurdle to overcome, the most challenging development?

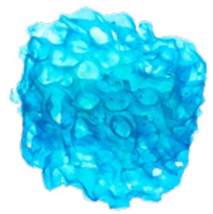
Translating a laboratory experiment of tomographic printing into a fully-featured product with a convenient, user-friendly software was a very challenging task. But our efforts paid off. Now we see that people are productive with our system from the first day of use, saving tons of time and frustration.

In 5 years, what is your vision regarding this technology?

We see the technology as a major enabler in personalized medicine. On one hand, the fast production of artificial biotissue from a patient's cells unlocks their potential use for drug screening on a massive scale. On the other hand, with plastics and soft materials, patient-specific parts can be generated at the point of care, which is particularly interesting for surgical planning, audiology and dentistry.

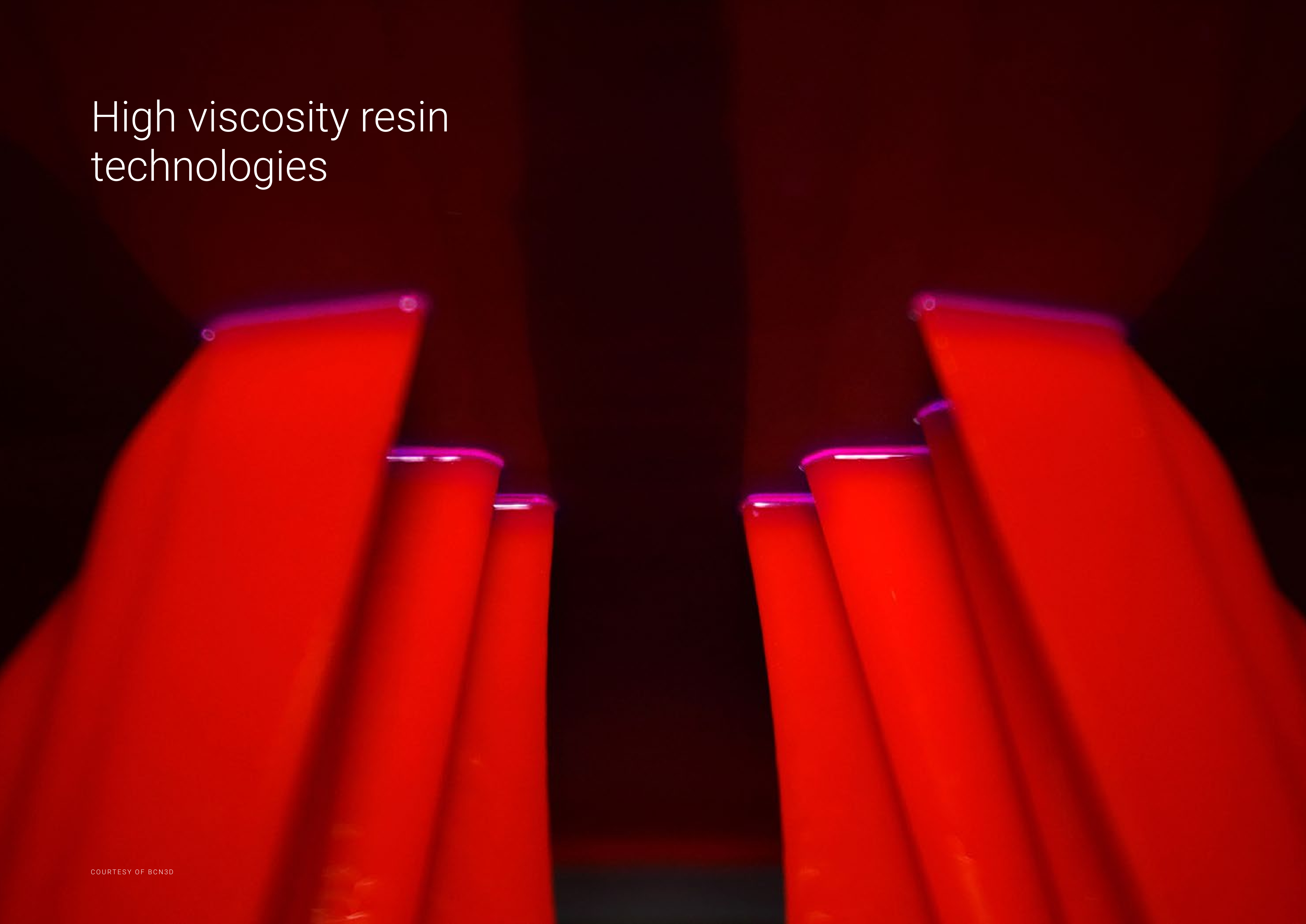
In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

We provide various container sizes, so that the volume of resin that is consumed in any given print can always be matched to the size of the object. In the same spirit, resins can be re-used thereby reducing waste. In general, this process requires only small amounts of energy because it does not depend on maintaining a given temperature or pressure for an extended duration in the build chamber.



COURTESY OF READLY3D

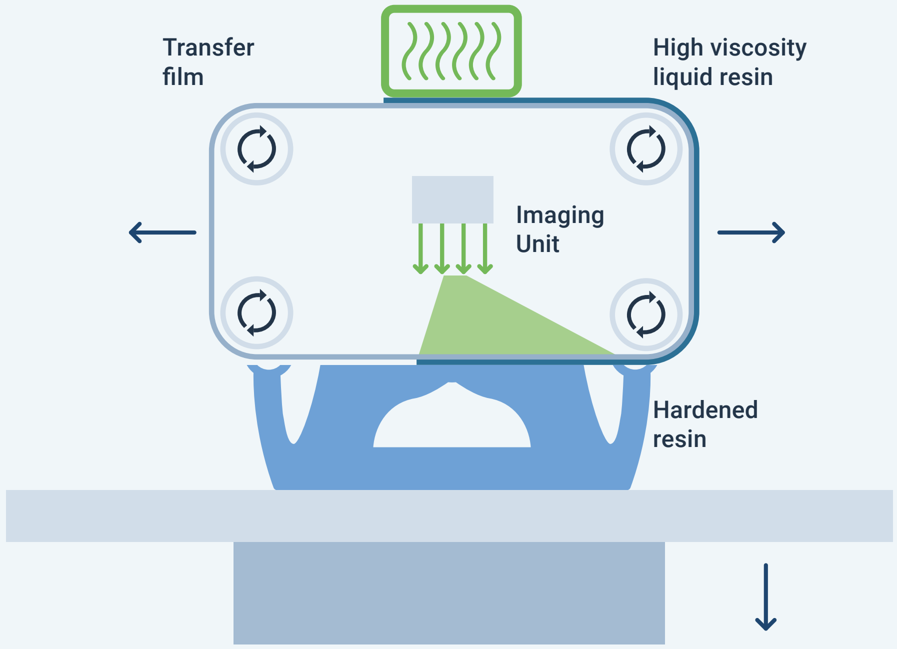
High viscosity resin technologies



COURTESY OF BCN3D

Area-wise Film Polymerization by CUBICURE

Area-wise Film Polymerization by CUBICURE is a Photopolymer Additive Manufacturing Technology that utilizes high viscosity resins to enhance material properties. This process aims at high productivity.



The Area-wise Film Polymerization is a new form of additive photopolymerization process. While conventional photopolymer systems utilize a vat as the material storage, CUBICURE has designed a continuous process, which uses a transparent film for material transportation. This technology is based on the HOT LITHOGRAPHY process heating up the material in order to reach a defined viscosity of the resin.
The first process step is to coat the transparent film with an even layer of material. Afterwards a roller system moves the transparent film with the applied material layer to the build platform. Once the high viscosity material is in contact with the build platform, a scanning unit moving along with the film cures the layer selectively. The application of material is possible in both directions to enhance the productivity of the system.
For the process to work the material has to be highly viscous in order to stick to the transparent film. This fact opens the opportunity to processing new resins, currently not manageable in other resin-based AM processes.

Potential

Combination of large build volume with high precision of polymerization

- **High productivity**
  with layer curing times of 60 to 90 seconds
- **Higher performance materials**
  Use of high viscosity materials to enhence photopolymer properties to industrial needs
- **Large build platform**
  Enabeling large build platform by use of dynamic projector

Technology Maturity Index

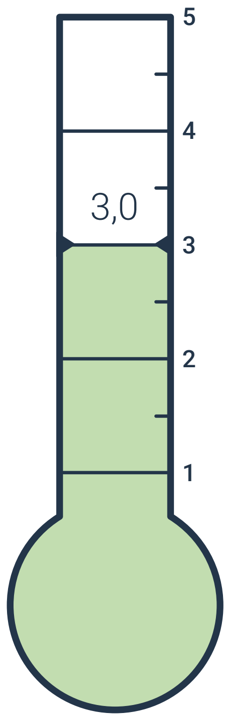
High throughput technology to challenge injection molding

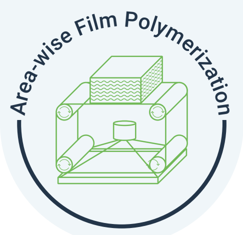
3 **Series production capability:**
Near production environment at first industrial users.

3 **Process capability:**
Production of parts for specific industries

3 **Machine concept:**
First serial systems delivered to customers.

3 **In-process quality control:**
Quality control is integrated in system





Interview with CUBICURE

What was the initial idea to look into the technology?

Looking to various AM technologies, it is clear that not every AM core technology can be scaled to an industrial relevant factor. For the founders of CUBICURE, this scalability of the technology itself as well as a real industrial meaning was key for selecting 'our' additive manufacturing approach. In terms of core technology, we think that photopolymers can provide this industrial scale factor better than other known AM technologies.

When and what was the situation where you realized this is something we can go to market with?

The team behind CUBICURE was practicing SLA and DLP processes on a high level at TU Wien in connection with very detailed questions of material and process performance in mind. When we found new ways to process high viscous slurries and resins, we realized that commercializing this technology can bring tremendous benefits for the AM world.

Can you summarize the unique selling point of your technology?

The ability to process high viscous photochemical raw materials is a game changer in photopolymer performance. This means better processes open the door for better materials. At CUBICURE, we call this approach 'Hot Lithography'. CUBICURE combines process and material knowhow and optimizes along the following goals: provide the best performing photopolymers in terms of mechanics, thermo-mechanics and long-term behavior and provide the most sophisticated AM printing machines in terms of accuracy and throughput. To do so, CUBICURE is solely focusing on industrial customers.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

Different AM Technologies have different pros and cons. The biggest Pro of photopolymers is the fact that you can build very accurate printing processes. Traditionally, the biggest Con always has been a poor material performance – this is changing now. If a photopolymer material can fulfill the requirements of a target application, there won't be another AM process to beat its industrial scalability potential. Neither in technological meanings nor in costs. Producing polymer parts on industrial scale therefore solely competes with injection molding. In general, you cannot beat injection molding in direct production costs. For some application you might beat it in technological aspects – allowing unique products which can not be mold. However, if additional aspects like time to market, innovation cycles, product iterations or customization, spare part management, production lot fluctuations or general risk of the production campaign (e.g. ramp up risk) plays a role for an application, Hot Lithography can be the ideal solution for a production scenario.

Where do you see boundaries or limitations?

Adding material always takes time. This means for every AM technology there is a quite linear connection between part volume and production costs. Of course, benchmark values in throughput can be offset between different AM techniques but the general rule stays the same. This means, part volume per se is a general boundary for AM processes. At least from an economic standpoint. Photopolymer approaches are best for the production of small and rather complex parts.

Quick facts on CUBICURE

Founding of company: 2015
Investors: AM Ventures, Align Technology
First material: CUBICURE Evolution
First industry: Connector Industry, Medical Industry
First application: not disclosed
Availability: Availability: Since 2017 (Caligma ®) and 2021 (Cerion ®)

What has been the most challenging hurdle to overcome, the most challenging development?

CUBICURE developed completely new lithographic printing processes: Our first machine Caligma® bases upon traditional vat-based concepts but features a series of unique process features, enabling the processing of high viscous photopolymers. With our big machine (Cerion®) we pioneered to completely unknown territory in terms of processing photopolymers. This is an industrial process which tremendously scales in throughput and homogeneity of printing quality. Our team spent four years in development before introducing the process to the community. This development was definitely challenging. Now, it is a game changer for lithographic AM.

In 5 years, what is your vision regarding this technology?

We already see the ramp-up of Cerion® production infrastructure at some of our pilot customers. In 5 years we will see series production of specific polymer parts in at least three different target industries. Series production in this context means millions of parts produced every year.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

Lithographic AM shows very low energy consumption when compared to other polymer shaping techniques such as injection molding. Moreover, due to its pure digital character, no tools or molds are needed, and a new part geometry can be produced without physical process modification. This completely removes the starting risks of a production campaign and makes the manufacturing of a part series easily available. It further reduces the need for part storage and enables real on-demand manufacturing.

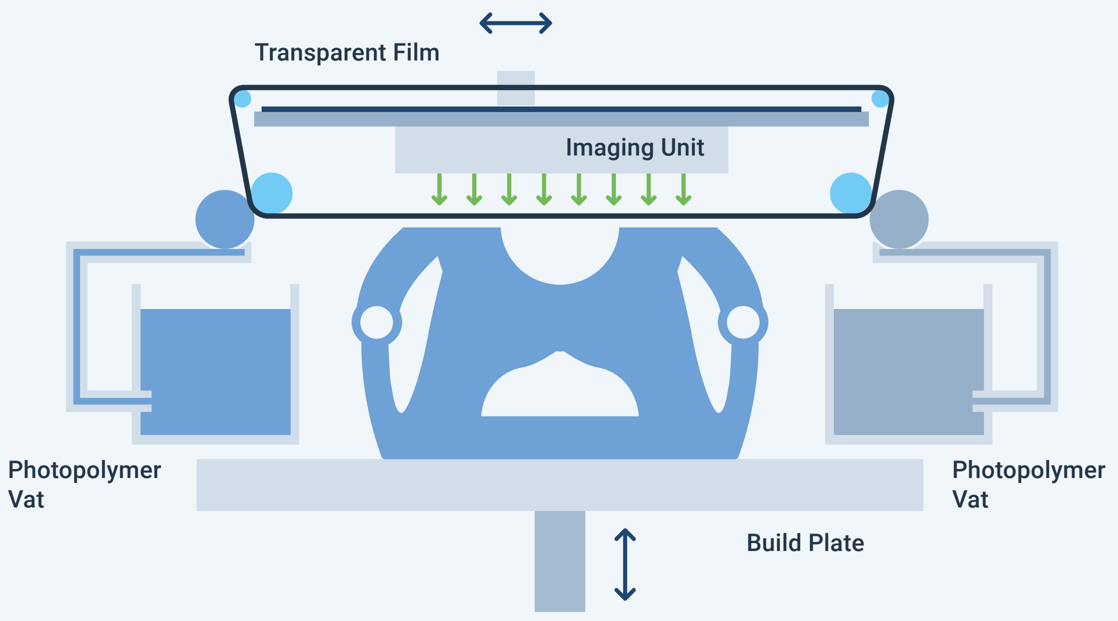
Robert Gmeiner

CTO at CUBICURE

PhD in Mechanical Engineering
10 years' experience in the field of lithographic Additive Manufacturing

Area-wise Film Polymerization by BCN3D

Area-wise Film Polymerization or Viscous Lithography Manufacturing as the process is called by BCN3D is designed to utilize high viscosity resins.



The printer itself consists of two resin vats placed opposite to each other, with the printing area in between. Above the printing area and the containers is a roller system that moves a transparent film uniaxially in both directions and is coated with the high viscosity resin. Due to the high viscosity, the resin sticks to the film and can be moved into the printing area. To create a layer, the printing platform moves upwards until it touches the film. When the material touches the printing platform, the resin is partially cured by using UV light from above. The material film and the printing platform disconnect during curing and the process starts again.
With its tow separate resin vats the process can use two different materials, for example one support material and one part material, otherwise both vats could also be used with the same material, to increase productivity.

Potential

High viscosity resin printing with enhenced material properties

- **Closed-material-loop**
  By recycling of the material there is only little waste
- **High viscosity materials**
  High viscosity materials enhance material properties and aim at thermoplastic characteristics.

Technology Maturity Index

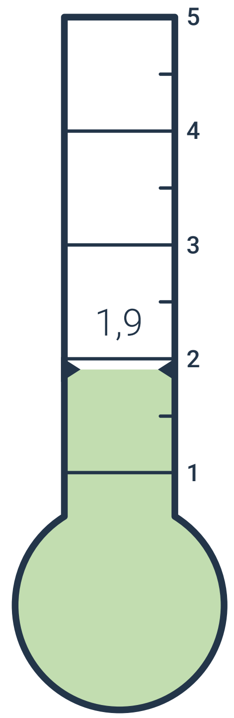
High viscosity material printing at low costs

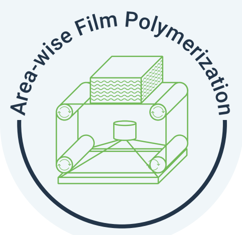
2 **Series production capability:**
System is still in development and has yet to prove series production capabilities.

2 **Process capability:**
Process variance, need for fine tuning

2 **Machine concept:**
No serial machines available.
Beta systems will be shipped in 2023

1 **In-process quality control:**
Basic machine with no dedicated process control





Interview with BCN3D

What was the initial idea to look into the technology?

VLM 3D printing technology, based on high viscosity resins, stems from the conviction that we want to give greater manufacturing autonomy to industries around the world and to respond to their current demand to produce locally and in close proximity to their production sites.

When and what was the situation where you realized this is something we can go to market with?

AM has the potential to allow for local manufacturing and ensure companies have better control of their supply chains. Three years ago, under this vision, we started the research and development of a new additive manufacturing technology - Viscous Lithography Manufacturing (VLM™) technology - with our sights set on building towards this dream.

Can you summarize the unique selling point of your technology?

VLM technology is BCN3D's proposal to bring manufacturing autonomy to the companies. It is a unique technology on the market that puts together part performance, productivity, and accessibility.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

We see as potential competitors, when we launch the hardware of the new VLM technology, since we have only announced the new patented technology this year 2022, the manufacturers of 3D printers with SLS technology. But we will be using high viscosity resins and the new VLM Technology. This will enhance the strengths compared to the other manufacturers currently using resins in the additive manufacturing market.

Where do you see boundaries or limitations?

We are exploring uncharted territories in terms of viscosity and non-Newtonian resins. We have printed from viscous resins to highly filled resins and thixotropic pastes, and we are in the process to balance the benefits of those formulations with an easy and clean printing process. Each formulation requires adjustments of the process parameters, so we are working with our chemical partners in defining the sweet spot where VLM can stand out compared to existing alternatives without compromising the accessibility of the process.

COURTESY OF BCN3D

Quick facts on BCN3D

Founding of company: 2019
Investors: undisclosed
First material: undisclosed
First industry: undisclosed
First application: undisclosed
Availability: Beta systems will be shipped in 2023

What has been the most challenging hurdle to overcome, the most challenging development?

Developing the technology without having access to high viscosity resins, optimized for our novel process, has been very challenging. Other critical aspects have been:

- the interaction between the resin and the transfer film
- defining critical parameters to ensure a robust process (in other words, which are the main mechanical systems to keep controlled at all times)
- developing a reliable multi-material strategy

In 5 years, what is your vision regarding this technology?

In 5 years we will have launched hardware, materials and software and we are sure that many companies will have already adopted VLM as their main AM tool to cover a large part of their production process applications "Gain full control over every stage of your production processes".

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

VLM also uses monocomponent resins formulations at room temperature to avoid pot life limitations and speed up setup times. Thanks to its proprietary lamination system, the absence of a resin vat means that no initial investment of resin is required. What's more, with VLM, zero waste becomes a reality: designed to filter and recirculate resin, every drop of resin eventually becomes a printed part.

Eric Pallarés
CTO at BCN3D

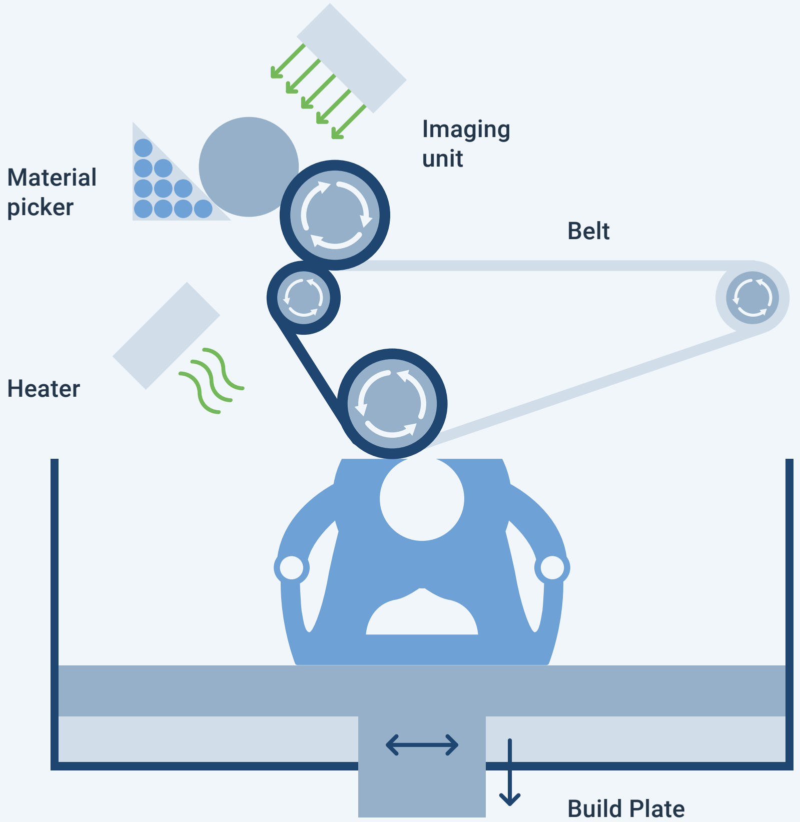
Industrial engineer (Master of engineering at Universitat Politècnica de Catalunya)
8 years experience in product management

Powder technologies

COURTESY OF EVOLVE

Electrophotography Lamination by EVOLVE

The Electrophotography Lamination process is a patented manufacturing process which was developed by EVOLVE. The technology was published under the name Selective Thermoplastic Electrophotografic Proces (STEP).



The Electrophotography Lamination process is a 2D printing process taken to the third dimension. It utilizes an available digital press (NexPress by KODAK) for high speed 2D printing. But instead of using toner to print on paper, EVOLVE uses thermoplastic powder to generate polymer sheets that are stacked to three dimensional parts.
At first a light sensitive image cylinder is electrically charged. An imaging unit lowers the charge in the desired area representing the negative of the next layer. The cylinder moves along dry material particles with sizes of 20 to 25 µm, which stick to the remaining charged area. From the cylinder the powder particles are transferred to a belt system. After the alignment of layers, the fusing step is initiated. Each layer is heated while traveling on the belt. This causes the layer to partially sinter. At the same time, the previously applied layer is heated again causing fusing of both layers. The fusing is supported by the application of pressure by the belt system.
In total five different materials can be applied in one layer due to five separate imaging units. Currently the final part is surrounded by a water soluble material. This material serves as a support and prevents the part from deformation during the application of pressure. During a post processing step the support is washed off.

Potential

Multi material prints and high speed printing

- **Low material cost**
  Use of standard thermoplastics such as ABS, Nylon or TPU
- **Multi material prints**
  Up to 4 part materials and 1 support material
- **High productivity**
  with layer times of up to 5 seconds to achive build rates of around 4500 cm³/h

Technology Maturity Index

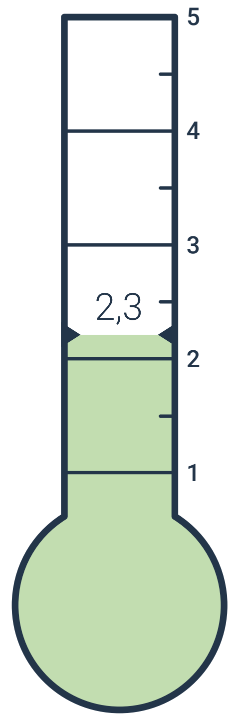
Series production for small thermoplastic parts

2 **Series production capability:**
First applications in testing.

3 **Process capability:**
Wide range of applications due to use of standard thermoplastics

2 **Machine concept:**
Beta machines installed are installed and industrial partner are involved in development

2 **In-process quality control:**
Sensors tracking system parameters.



Interview with EVOLVE

What was the initial idea to look into the technology?

The initial idea was to leverage electrophotography, already successful in 2D production printing, to 3D production printing.

When and what was the situation where you realized this is something we can go to market with?

In 2015-16, we made the first product-like prototype with the component technologies and successfully refined it to achieve impressive part quality with engineering thermoplastics and showed the potential for productivity needed for end-use parts.

Can you summarize the unique selling point of your technology?

A unique combination of part quality, productivity, part cost and multi-material capability. This unique combination of attributes make the technology very attractive for additive manufacturing.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

HP's Multi-jet Fusion, Selective Laser Sintering are technologies that compete with our technology. We have complementary characteristics to injection molding.

Where do you see boundaries or limitations?

The parts made from this process are limited to a height of less than 100 mm in building direction.

COURTESY OF EVOLVE

Fast facts on EVOLVE

Founding of company: July 1, 2017
Investors: LEGO, AMVG, Stanley Black and Decker
First industry: Consumer goods and electronics
First application: electronic scoreboard panels
Availability: Available from 2021

What has been the most challenging hurdle to overcome, the most challenging development?

Achieving a combination of part quality, productivity and low operating costs.

In 5 years, what is your vision regarding this technology?

The dominant polymer productive additive manufacturing technology for end-use parts.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

This process uses support materials to preserve geometry, and we have been able to reduce our support usage by 20-50% due to our unique software and build process capabilities. This technology readily produces surfaces with low surface roughness without the use of vapor smoothing solvents or chemical processing.

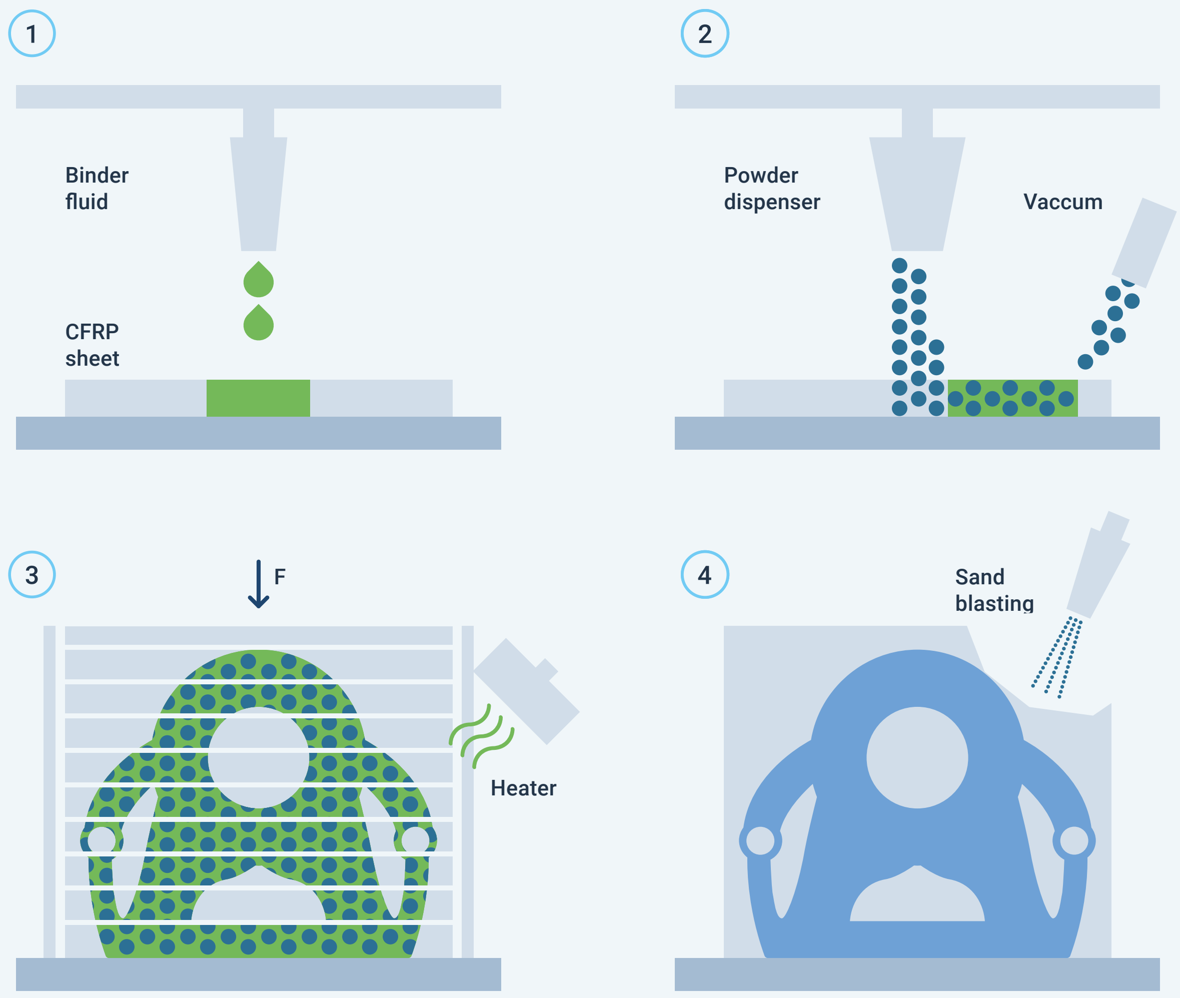
Dr. Arun Chowdry

SVP Emerging Technologies and Applications

30+ years of Technology and Commercialization leadership experience at NexPress and Kodak
As CTO & VP of the NexPress JV, led technology and commercializatio teams in US and Germany to help bring the highest quality and most reliable digital printing press to market

Continuous Fiber Sheet Lamination by IMPOSSIBLE OBJECTS

Continuous Fiber Sheet Lamination also called Composite Based Additive Manufacturing was invented by IMMPOSSIBLE OBJECTS, a Chicago based company. The technology combines continuous fiber sheets with thermoplastic powder.



The process starts with the insertion of 50 μm thick composite sheets, which is approximately half the thickness of a sheet of paper. Commonly used materials are carbon or glass fiber, depending on the requirements of the final component. While carbon results in higher strength, glass fiber is cheaper. The next step is the application of a binder fluid on the composite sheet, which is applied in the exact position where the component will be created. Afterwards a fine-grained powder is applied and adheres to the areas covered with fluid. A vacuum removes the excess powder particles, and each sheet is deposited and stacked on previous prepared sheets.
To produce the final component, all sheets are heated to a maximum of 400°C (depending on the material) and simultaneously pressed in z-direction. Areas that were not covered by the binder fluid and powder, are removed by sandblasting or blasting using solid carbon dioxide (dry ice).

Potential

High strength parts with continous fiber reinforcement

- **Commodity long fiber sheets**
  Carbon fibre reinforced plastic and sheets fused by pressure enable high strength
- **Low cost**
  Large market of powders is available, use of recycled powder possible
- **Wide range of applications possible**
  Unmanned air vehicle, motor sport etc.

Technology Maturity Index

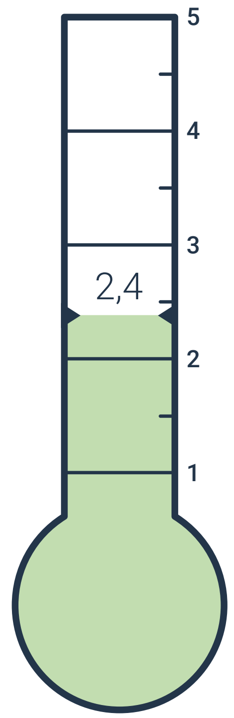
Technology with advanced state of developing

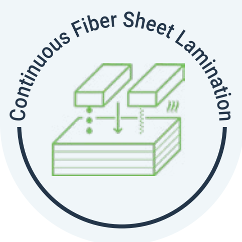
2 **Series production capability:**
First applications in testing.

3 **Process capability:**
The process yields solid parts.
Independent analysis of properties missing.

3 **Machine concept:**
Industrial systems are already producing.

2 **In-process quality control:**
Sensors tracking system parameters.





Interview with IMPOSSIBLE OBJECTS

What was the initial idea to look into the technology?

The founder Bob Swartz grew up in a printing company and saw the speed, size scalability and robustness of commercial 2D printing. Bob envisioned a new way to build on commercial printing capabilities by using fiber reinforced materials and depositing a powder for the third dimension to a printed sheets which gave birth to the Composite Based Additive Manufacturing (CBAM) additive technology.

When and what was the situation where you realized this is something we can go to market with?

3D printing was gaining increased global awareness and the founder Bob Swartz saw the limitations of many of the existing 3D printing technologies. Many of the current 3DP technologies have slow build speeds, limited material options, expensive build materials and low material properties. The CBAM technology provided fast build speeds with strong materials be demanded for a number of high value industrial applications.

Can you summarize the unique selling point of your technology?

Fast build speeds, similar strength to weight properties as compared to aluminum and 60% lighter weight than aluminum.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

Compression and injection molding processes requiring discrete tooling are the competing manufacturing technologies

Where do you see boundaries or limitations?

Limiting factor will be how tall of composite parts can be built. Build height becomes a function of the size of heating and pressing equipment available for consolidating the fiber sheets together.

COURTESY OF IMPOSSIBLE OBJECTS

Fast facts on IMPOSSIBLE OBJECTS

Founding of company: 2012
Investors: OCA Ventures, Idea Fund and many private investors
First material: Carbon fiber nylon 12
First industry: Aerospace
First application: Drone parts for Aurora Flight Sciences
Availability: In 2017 CBAM1 3D printing system , 2019 followed CBAM2

What has been the most challenging hurdle to overcome, the most challenging development?

Challenges with build material variability and creating appropriate material specifications and quality measures to address this matter. An on-going challenge is continuing to find ways to reduce the level of void content in final composite part.

In 5 years, what is your vision regarding this technology?

High speed 3D composite printing at 15 to 30 meters/minutes to provide a cost-effective manufacturing solution at scale that competes with injection molding processes.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

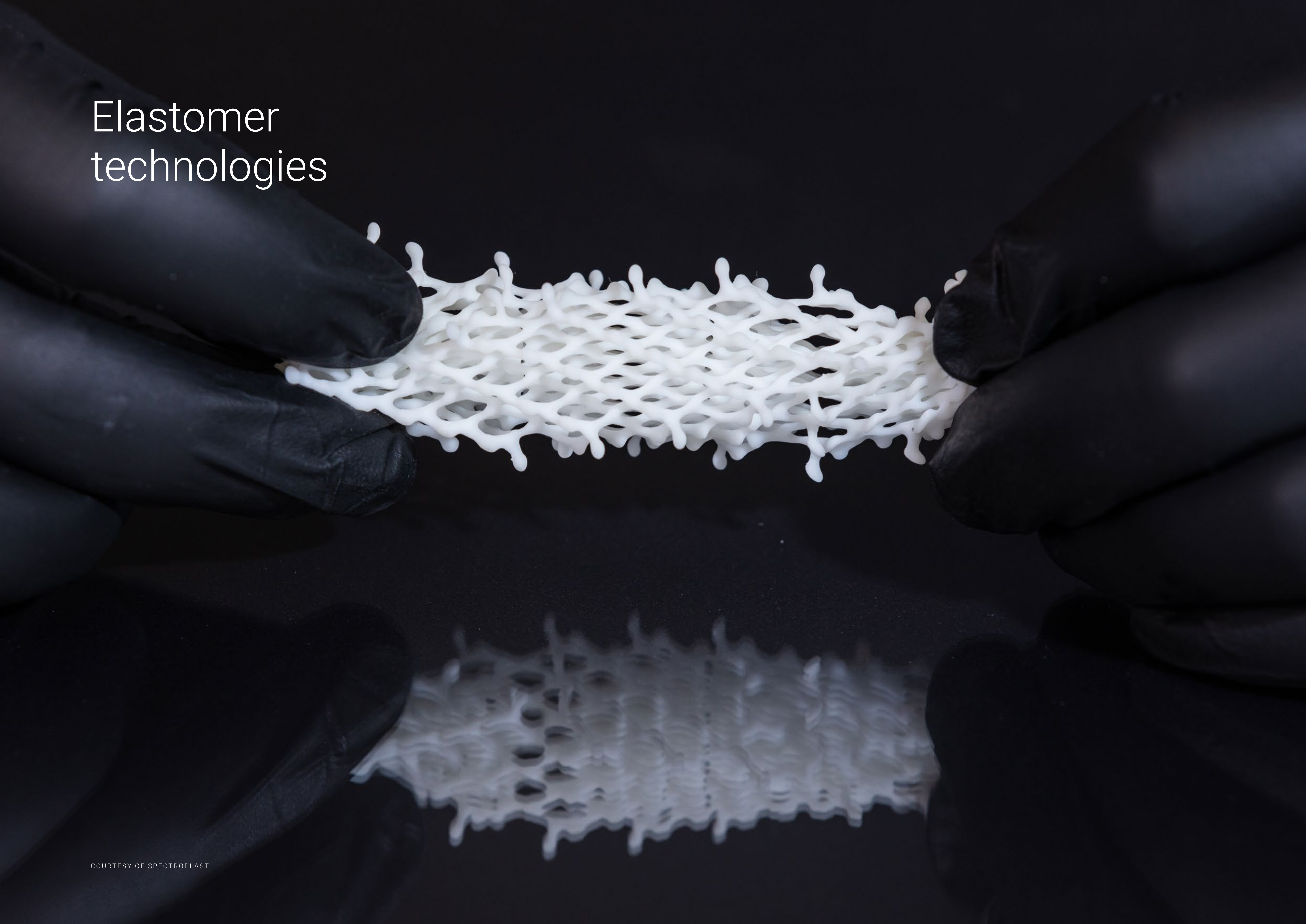
CBAM process can use recycled materials and the materials not used in the part build can be recycled for a sustainable manufacturing solution.

Jeff DeGrange

Chief Commercial Officer of IMPOSSIBLE OBJECTS

Master of Science in manufacturing engineering from Washington University and Bachelor of Science in industrial engineering from the University of Iowa
Technical Committee Co Chairman for Society of Manufacturing Engineering (SME) Additive Committee

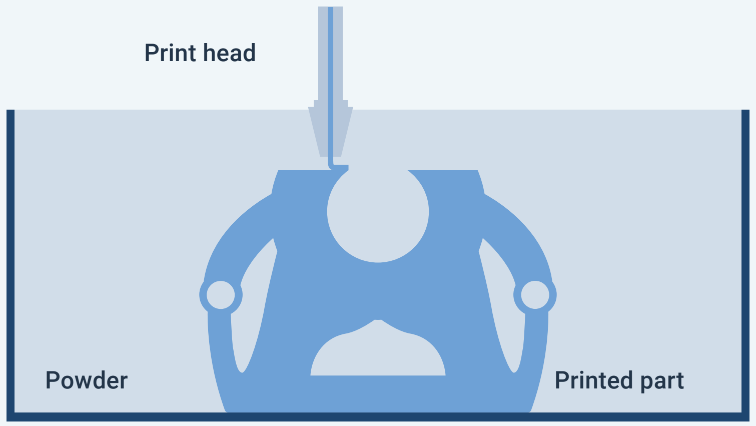
Elastomer technologies



COURTESY OF SPECTROPLAST

Elastomer Deposition by 3DEUS DYNAMICS

This Elastomer Deposition approach was developed under the name Dynamic Molding by the French company 3DEUS DYNAMICS. Unlike conventional molding, Elastomer Deposition uses an adaptable flexible mold in form of fine-grained powder.



The main components of the process are the three- or six-axis print head and a vat filled with powder. To generate the part geometry the printhead is lowered into the powder vat and selectively deposits silicone material. The powder, whose particles have a size of around 100 µm, acts as a "dynamic" mold and support structure. The powder as the surrounding medium can be used as this dynamic support structure but can also be implemented in the silicon material to achieve additional material characteristics like electrical conductivity. This allows a high grade of design freedom, overhangs and undercuts included. The resulting possibility to produce individual parts within one assembly makes the technology interesting for one-off parts or prototypes, that can't be produced with conventional molding.
After the geometry finished the powder vat is transported to an oven to cure the silicone through application of heat. Afterwards the parts are removed from the vat and the powder can be recycled and reused.

Potential

Economic production of one-off elastomer parts

- **Multimaterial prints**
  Silicone is able to react with the powder to get characteristics like electrical conductivity
- **Wide range of silicone hardness**
  Range from shore A0 to A90
- **Design freedom**
  Overhangs, undercuts and individual parts in one assembly

Technology Maturity Index

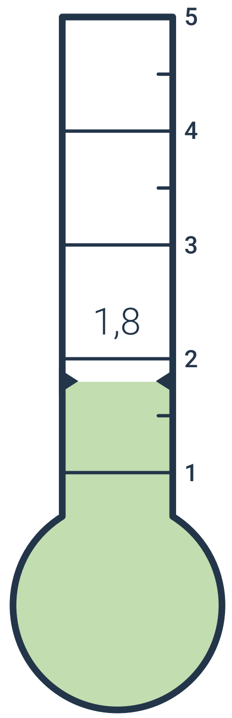
Elastomer printing with high resolution

2 **Series production capability:**
Single-part or single-assembly production.

2 **Process capability:**
Elastic parts for mainly medical use.

1 **Machine concept:**
Proof of concept machines

1 **In-process quality control:**
No sensors.



Interview with 3DEUS DYNAMICS

What was the initial idea to look into the technology?

The idea was to be able to print fluid materials such as silicones by avoiding the use of a support structure, their reformulation and their collapse during printing. From there, we have developed a process in a granular environment: dynamic molding.

When and what was the situation where you realized this is something we can go to market with?

We had the idea to create 3DEUS DYNAMICS when we realized that our process could allow the printing of complex structures never before obtained by other additive manufacturing processes. In addition, market access has been strengthened because our process is the only additive manufacturing process capable of obtaining new flexible composite materials unknown to date.

Can you summarize the unique selling point of your technology?

Our dynamic molding technology is the only one capable of printing all types of fluid materials without geometry limits and without chemical reformulation.

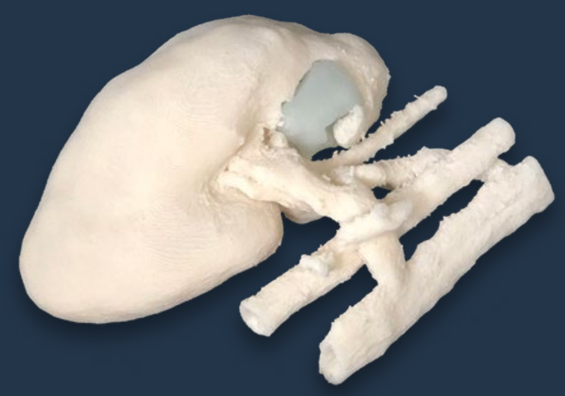
What other AM or traditional manufacturing technologies do you see as competition to your technology?

For silicones: DLP technology from SPECTROPLAST and Fresh technology from Fluiform; for multi-material printing extrusion technology from LYNXTER.

Julien Barthes

CEO & Co Founder of 3DEUS DYNAMICS

Two masters' degrees in engineering and polymer chemistry and a PhD in biomaterial science from Strasbourg University Strasbourg University 6 years in medical device development with a strong focus on tissue engineering and 3D printing C reated 3Deus Dynamics After a collaborative project with 3dFAB academic platform



COURTESY OF 3DEUS DYNAMICS

Fast facts on 3DEUS DYNAMICS

Founding of company: 2020
Investors: Elkem Silicone, PartnerGil , 33 Californie
First material: Silicone
First industry: Healthcare
First application: Medical devices
Availability: 2024

Where do you see boundaries or limitations?

The main limitation is the scientific understanding of the biphasic flow that governs our dynamic molding process.

What has been the most challenging hurdle to overcome, the most challenging development?

The main hurdle was to find the best candidate powders for silicone materials. One of the important points is also to develop post-processing tools for silicone and flexible composite applications.

In 5 years, what is your vision regarding this technology?

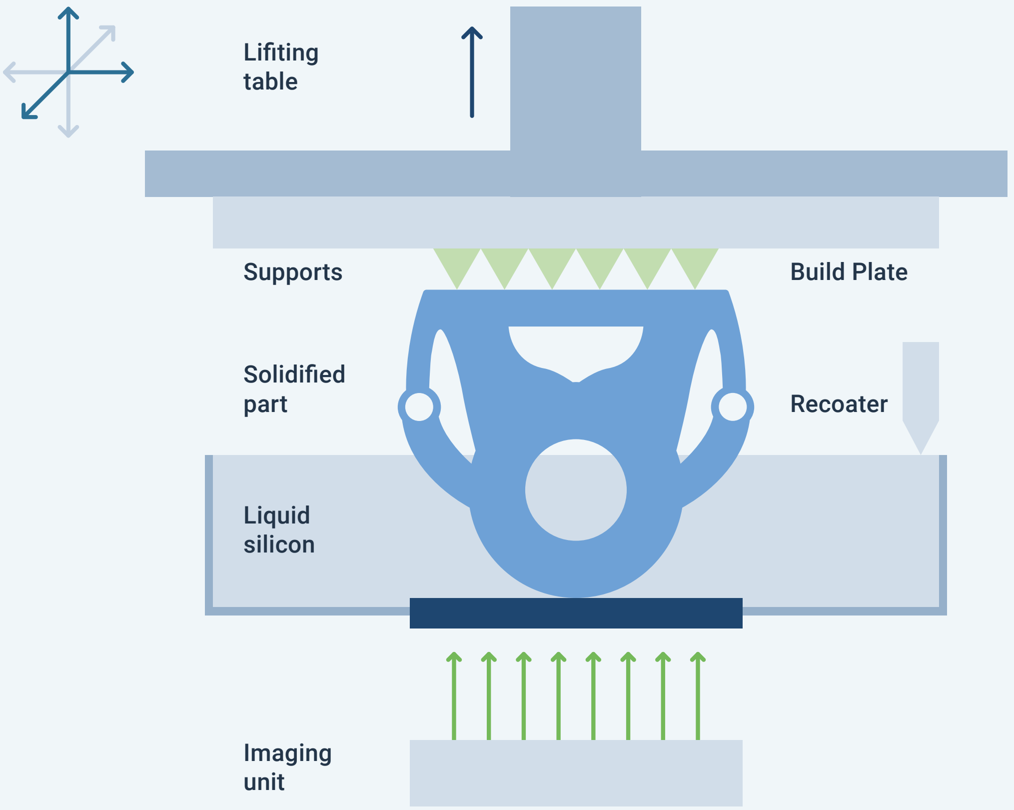
We will offer production lines for printing all types of extrudable materials and their composites for all application markets, primarily medical, aeronautics and defense.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

We use a 100% reusable powder. It is a printing technology without failure and our process is without support structure which avoids any waste of materials. We have a process that adapts to all extrudable materials, which limits the number of printing machines.

Vat Vulcanization by SPECTROPLAST

Vat Vulcanization was developed by SPECTROPLAST under the name of SILICON ADDITIVE MANUFACTURING. The initial idea for developing the process was to print individual parts for medical customers using the high viscous silicon material.



Vat Vulcanization is based on the principles of Area-wise Vat Photopolymerization where the material is cured selectively by a UV-light source layer by layer. The difference in Vat Vulcanization is that the material is not a thermoset but a true silicone. These silicones used have elastic material properties and can be used in medical applications.
In detail, a coater distributes a silicon material in a silicone vat evenly. The build platform is then lowered into the silicone vat and a UV light is set to the designated areas to initiate the vulcanization process of the elastomer. After curing, the platform lifts by the thickness of a layer and the process starts from the beginning. The silicone shore hardness ranges from A20 to A60.

Potential

Silicone printing for multiple applications

- **Applications for medical use**
  Certified according to ISO DIN EN 10993-10 for the use of applications with skin contact, sterilized afterwards
- **Advantage over injection moulding**
  Minimum wall thickness of 0,4 mm
- **Short lead times**
  and potential for customization

Technology Maturity Index

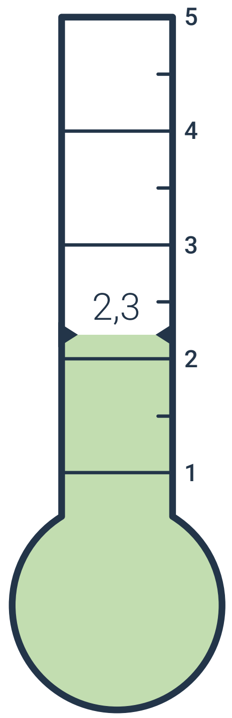
Prototype machine and start of machine sale

2 **Series production capability:**
Individual part production.

2 **Process capability:**
Elastic parts for mainly medical and consumer goods.

1 **Machine concept:**
Service provider for customers. Started machine sales in 2022.

1 **In-process quality control:**
not disclosed



Interview with SPECTROPLAST

What was the initial idea to look into the technology?

During my PhD at ETH Zurich, I was involved in a project to 3d print patient-specific aortic heart valve replacements. Silicone is the go-to material for medical applications, but there was no silicone 3d printing technology on the market.

When and what was the situation where you realized this is something we can go to market with?

After some press releases, we had an overwhelming response from customers all around the globe that showed profound interest in the technology.

Can you summarize the unique selling point of your technology?

SPECTROPLAST is the first company to offer high-precision silicone additive manufacturing solutions for the industrial and medical market. All our materials are certified for biocompatibility and our systems reach a resolution and throughput that are on eyelevel with injection molding. With Silicone Additive Manufacturing (SAM), end-use silicone products are manufactured and shipped to our customers within days, cutting costs and lead time by 10x compared to injection molding. On top, SAM reduces energy consumption by 99.9% and material waste by 85%.

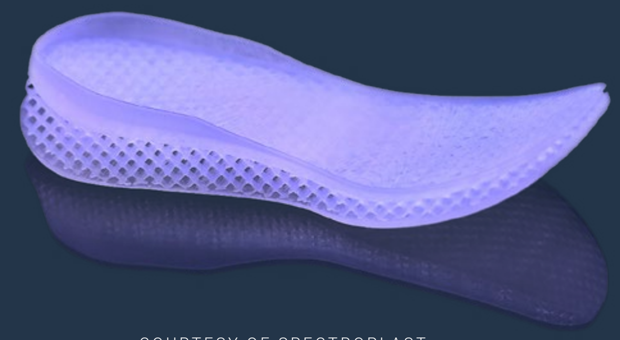
What other AM or traditional manufacturing technologies do you see as competition to your technology?

There are extrusion-based silicone 3D printing technologies on the market with a 10x lower resolution and 100x lower printing speed.

Manuel Schaffner

CEO and Chairman of SPECTROPLAST

PhD in Material Sciences from ETH Zurich,
Developed Silicone Additive Manufacturing that resulted in the incorporation of SPECTROPLAST AG in 2018.



COURTESY OF SPECTROPLAST

Fast facts on SPECTROPLAST

Founding of company: 2018
Investors: AM Ventures
First material: TrueSil A30
First industry: Medical devices
First application: Pipette for eye surgery
Availability: August 2022

Where do you see boundaries or limitations?

Products that exceed dimensions above 300 x 300 x 300 mm. Multi-material printing is not yet feasible with SAM.

What has been the most challenging hurdle to overcome, the most challenging development?

Over the past years, SPECTROPLAST has shown cutting-edge innovation to make silicone accessible to the market, meeting a long-standing market need. Major innovations included the materials, hardware and market access.

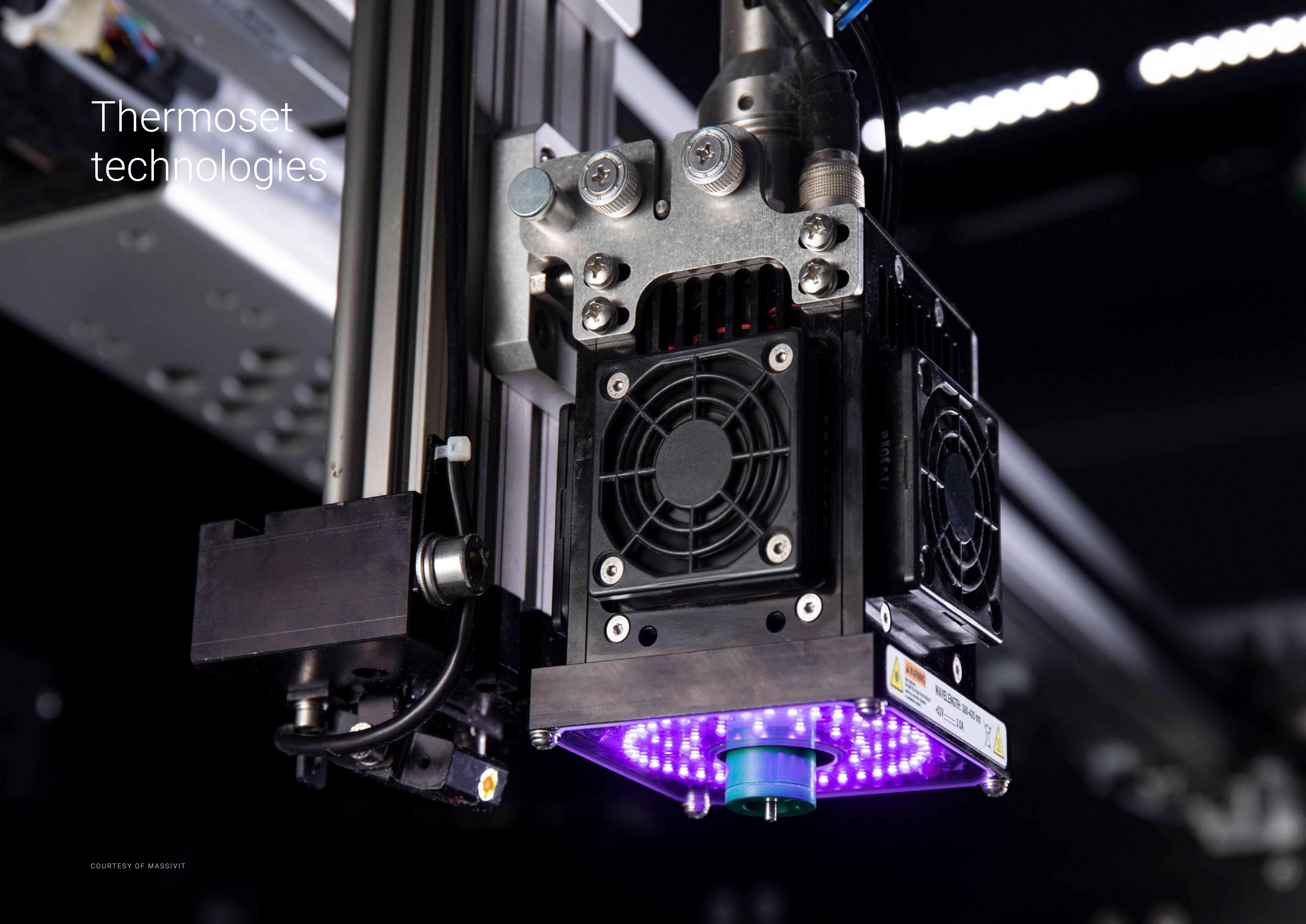
In 5 years, what is your vision regarding this technology?

In five years, SPECTROPLAST will be the enabling technology provider to manufacture patient-specific medical devices to improve patient's lives all around the globe.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

SAM is sustainable technology as it helps saving scares material and energy resources. With SAM, an end-use Silicone product can be manufactured in minutes while saving 99.9% in energy and reducing material waste by 85% compared to conventional injection molding.

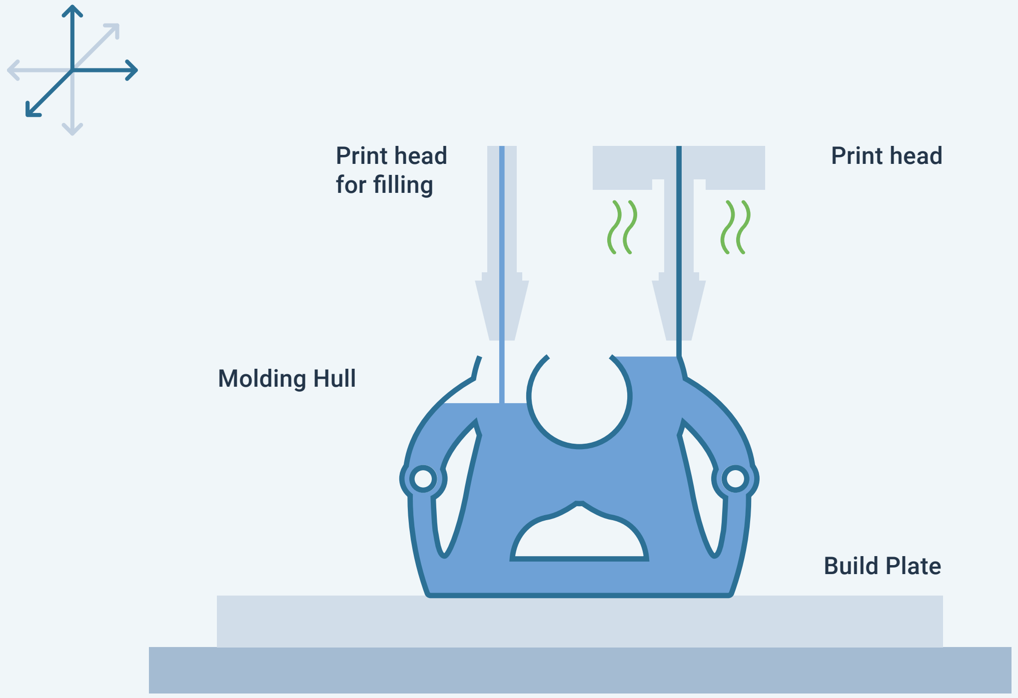
Thermoset technologies



COURTESY OF MASSIVIT

Thermoset Deposition by MASSIVIT

The technology developed by MASSIVIT 3D, an Israel based company founded in 2013 is designed to build large format prototypes, visual models and molds.



The Thermoset Deposition Technology is already established in several industries. Thermoset Deposition is based on a photo-polymeric gel that is applied by using a nozzle which is surrounded by a UV light, that cures the gel instantly after deposition. The fast curing process enables the production of parts with overhangs and limits the need for support to a minimum. The capability of supportless printing led to the development of an additional process, the so-called CAST IN MOTION. This process uses the Thermoset Deposition process to produce a molding hull. After five to ten layers the molding hull is filled with a thermoplastic gel by another print head. The process is repeated until hull and the part is completed.
When the process is completed the component and its shell are heated to 155°C to finalize the curing process. Afterwards the entire part including the shell are placed in a water bath initiating the decomposition of the hull, which is water soluble. Finally, the part is removed and further post processes to achieve the needed surface quality and final geometry can be applied.

Potential

Extremely large parts and resin-based production for molds

- **Wide range of applications**
  1450 x 1110 x 1800 mm build volume enables to produce large components
- **Useable for casting molds**
  Target market are casting molds, reducing process steps
- **Short lead times**
  Individual mold or large part can be printed in a matter of hours.

Technology Maturity Index

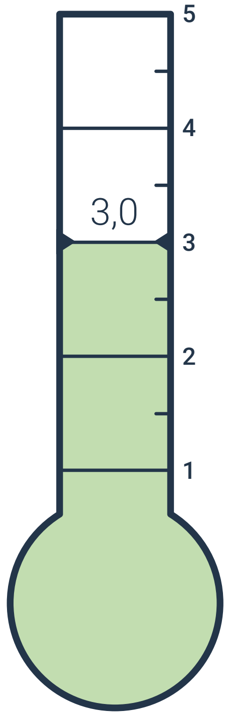
High advanced technology with first industrial machines

3 **Series production capability:**
Single parts and small series production printable.

2 **Process capability:**
Capable for multiple applications.

3 **Machine concept:**
First industrial machines sold.

1 **In-process quality control:**
not disclosed



Interview with MASSIVIT

What was the initial idea to look into the technology?

Our team of founders sought a solution to Additive Manufacturing market gaps in production speed, build volume, and high-performance materials. Our co-founder and CIO, Gershon Miller, devised an entirely new type of photo polymer printing gel that unlike FDM or SLS, cures on-the-fly with practically no need for support or infill. This allows for very large parts to be produced at up to 30 times the speed of existing technologies.

Can you summarize the unique selling point of your technology?

Our first product line, Gel Dispensing Printing, or GDP, enables manufacturers to produce full-scale parts, prototypes, and molds within a matter of hours instead of days or weeks. We're talking about a build volume of 1450 by 1800 by 1110 mm. There's actually no limit to production size because parts can easily be joined together. The machines have a dual-head printing system that allows for two separate objects to be printed simultaneously. Our latest large-scale 3D printer, the MASSIVIT 5000, enables parallel printing with a different material on each head. We've developed five purpose-specific materials for this product line that respond to industry needs including flame retardancy. I think that what astounds our customers the most is the ability of DIMENGEL to print vertical walls without support structures. It's quite extraordinary to watch live and also reduces associated waste as well as post-processing time.

What other AM or traditional manufacturing technologies do you see as competition to your technology?

Many of our customers traditionally used CNC machines to produce large, custom parts. One of the reasons they chose to adopt our technology is because they weren't able to achieve the degree of complexity, precision, and undercuts available with MASSIVIT 3D printers. In addition, CNC machining requires specific expertise and takes extensive time to configure. Machining also produces enormous waste and requires storage and handling of stocks. CNC equipment manufacturers now understand that they must also enter the AM market to respond to evolving needs in the manufacturing arena. Industries such as the automotive arena are still somewhat reliant on manual fabrication methods such as hand sculpting for prototypes. These processes likewise involve lengthy and complicated workflows that are wasteful.

Erez Zimerman

CEO of MASSIVIT 3D

BSc in Electrical Engineering and an MBA from Bar Ilan University
Zimerman was VP Global Sales at Massivit 3D for three years before becoming CEO

COURTESY OF MASSIVIT 3D

Fast facts on MASSIVIT 3D

Founding of company: 2013
Investors: Listed at Tel Aviv Stock Exchange, Stratasys, Yaskawa
First material: Dimengel 100
First industry: Visual Communciations
First application: Giant, complex displays for events and retail
Availability: The MASSIVIT 10000 is available for purchase and deliveries start in H2 2022

Where do you see boundaries or limitations?

As developers of materials, hardware and software, our teams are constantly devising features to further increase production speed, scale – and importantly – mechanical properties of the materials in order to overcome recognized AM challenges such as shrinkage.

In 5 years, what is your vision regarding this technology?

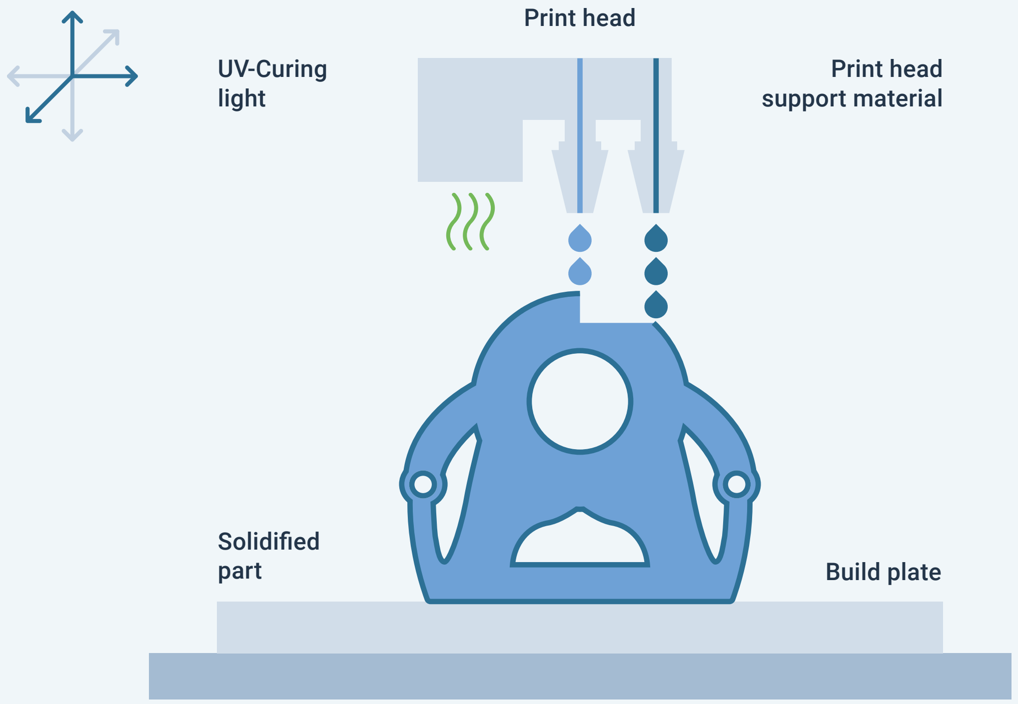
One of our company's ambitions, since its founding days, has been to empower manufacturers to "print the unprintable". We've so far developed a range of high-performance, thermoset materials suitable for all stages of manufacturing. Based on our first-generation Gel Dispensing Printing technology that has been adopted across 40 countries, we've recently launched a second-generation product line called Cast In Motion. The first to be launched in this line, the MASSIVIT 10000, is an additive tooling system for composite material parts. It enables molders to directly print epoxy-based, isotropic molds for a range of industries in up to 80% less time. Now that we've cracked the ability to digitally cast molds, tools, and masters as well as digitally print mandrels and prototypes.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

MASSIVIT 3D printers are frequently adopted by our customers to replace traditional processes such as CNC milling and hand sculpting that inherently require a huge amount of material waste, not to mention associated transportation needs, storage and disposal processes. Parts printed on MASSIVIT 3D printers are hollow and use only the necessary material for the end part. Unlike other additive systems, the parts can be produced with almost no support structures or infill. Once cured, MASSIVIT 3D parts are considered normal office waste. In addition, the pails that contain our materials are made of recyclable thermoplastic materials such as PP. Dimengel scrap material can be ground to be reused as fillers in new composite products.

Material Jetting by INKBIT

INKBIT, a Boston based AM company developed VISION CONTROLLED JETTING a new approach of the established Material Jetting process. It includes a closed-loop control system, which inspects each individual layer in terms of thickness and compensates deviations in the subsequent layer.



Material Jetting in general is a well-established AM process that has been around for decades. The basic principle of the technology is to deposit droplets of photopolymer material and cure each layer with a UV light source. INKBIT's innovation comes from a combination of new material capabilities and a closed-loop control system. During the process each layer is scanned by a laser scanning system after deposition. If the dimensions do not correspond to the specification, the error is compensated during printing of the next layer. Similar to other Material Jetting technologies INKBIT can print multiple part materials and one wax-like support material. The support material surrounds each part to enhance the surface quality. To remove the support after the end of the production cycle, the build platform is placed into and oven heated to 60°C. The wax melts off the components. Further need for post processing depends on the desired surface quality.

Potential

Resin-based production for high quality applications

- **Serial production capabilities**
  Large build volume of 500 x 250 x 200 mm makes it suitable for serial production
- **Closed-loop control system**
  Enables a high degree of accuracy and quality
- **Recyclable support material**
  Wax-like material can be recycled and reused

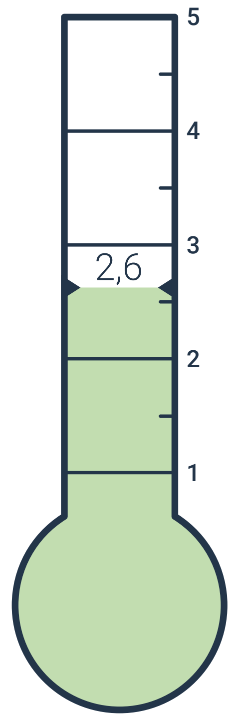
Technology Maturity Index

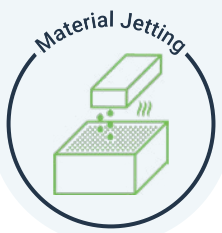
2 **Series production capability:**
Pre-production for some applications.

3 **Process capability:**
Capable process for specific parts

3 **Machine concept:**
First industrial versions installed.

4 **In-process quality control:**
Closed-loop-control-system for every layer.





Interview with INKBIT

What was the initial idea to look into the technology?

Our CTO, Wojciech Matusik, was a user of material jetting AM systems in his lab at MIT. Having a background in computer graphics, vision, and machine learning he set out to improve the capabilities of material jetting using a vision-based approach.

When and what was the situation where you realized this is something we can go to market with?

Once the proof-of-concept of vision based closed-loop 3D material jetting was demonstrated, it was clear that it this platform would enable additively manufactured parts, using tough polymers, to be printed in volume production.

Can you summarize the unique selling point of your technology?

Our technology produces cost-effective, highly accurate and repeatable parts at high volumes using tough polymer materials that are suitable for long term, end-use applications. Previously, AM technologies didn't enable users to accomplish all four of these with a single system platform.

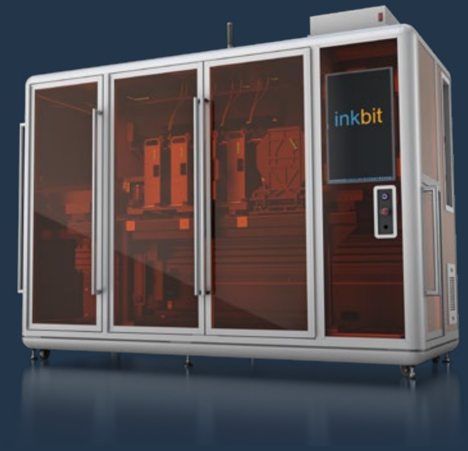
What other AM or traditional manufacturing technologies do you see as competition to your technology?

INKBIT Vista is a production machine. AM technologies capable of delivering production scale volumes are potential competitors. Smaller prototype machines are not competitors.

Eric Bert

Senior Vice President Commercial at INKBIT

BS in Mechanical Engineering, University of Massachusetts, Amherst
SVP of Sales – North America at STRATASYS



COURTESY OF INKBIT

Fast facts on INKBIT

Founding of company: 2017
Investors: undisclosed
First material: Vulcan Soft Elastomer
First industry: Healthcare
First application: Oral care device
Availability: 2022

Where do you see boundaries or limitations?

A limitation is the fact that the jetting process, while offering many benefits, is complex so the materials used need to be optimized for the process. As a result, users cannot easily introduce 3rd party materials into the Vista system.

What has been the most challenging hurdle to overcome, the most challenging development?

The biggest challenge was the development of our fundamental technology; a high-speed machine vision system and the feedback loop that it drives, enabling our VCJ process.

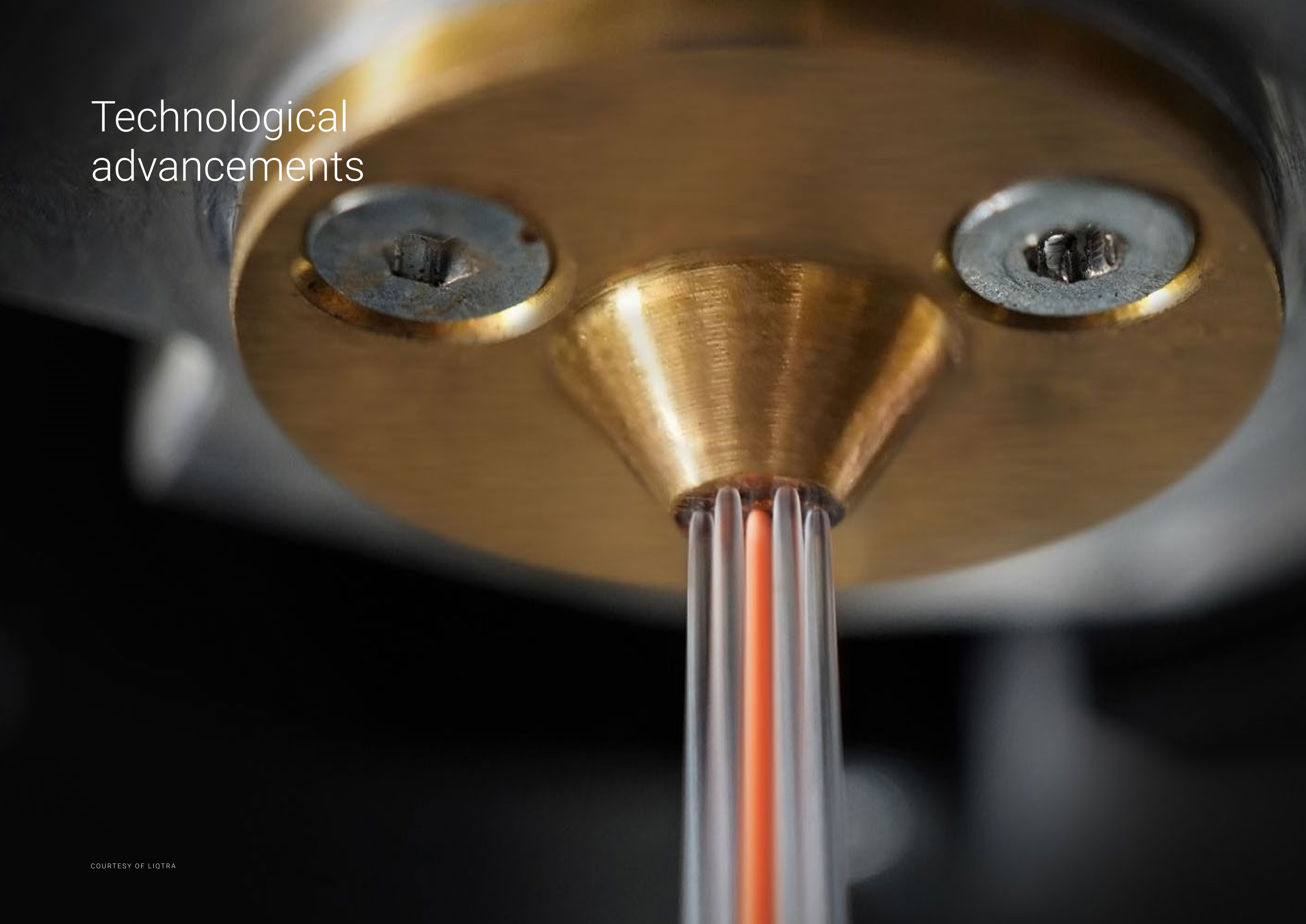
In 5 years, what is your vision regarding this technology?

The vision is for INKBIT to be the leading AM polymer production platform that allows users to successfully and cost-effectively mass produce complex 3D printed parts for end use applications.

In terms of environmentally friendly production, what are the particularly sustainable aspects of the process?

Our wax support material can not only be easily, and cost effectively removed but can also be recycled. Our scanner ensures that build material is used efficiently, vastly reducing the amount of waste produced by the system compared to other technologies, and our post processing workflow does not use hazardous materials.

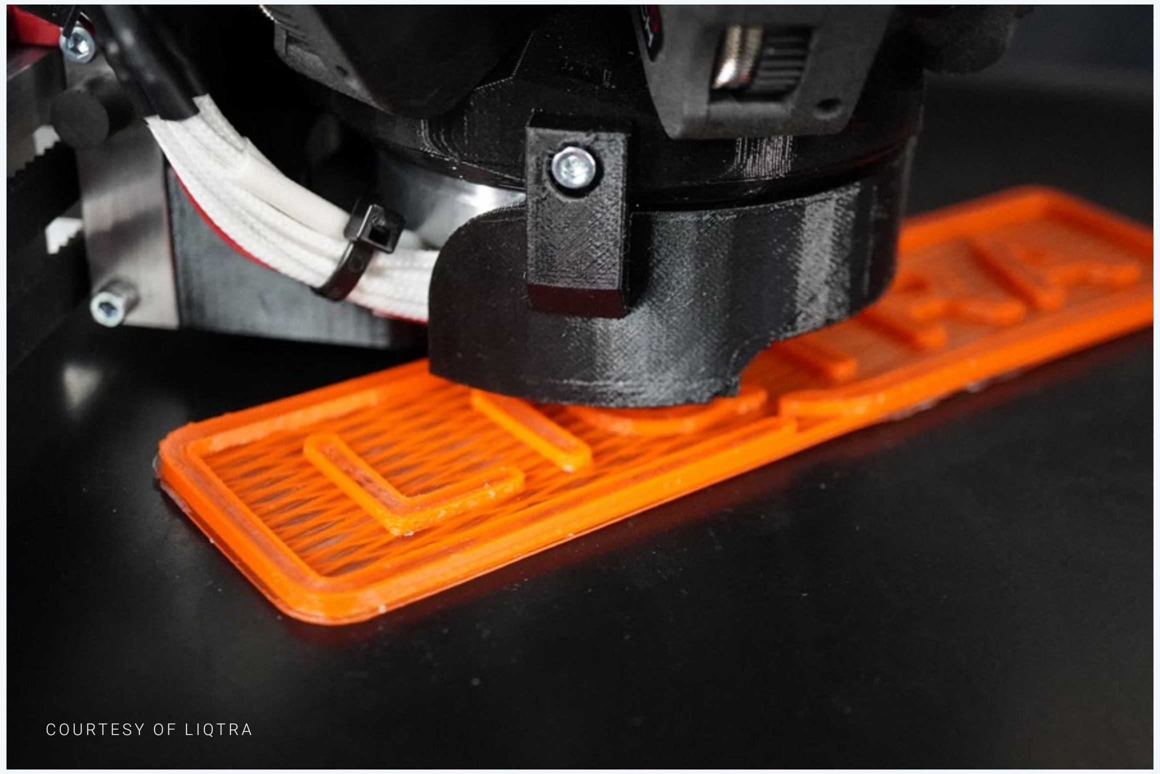
Technological advancements



COURTESY OF LIQTRA

Multi Nozzle Material Extrusion by LIQTRA

LIQTRA a Hamburg based company has developed a new approach to increase the productivity of Material Extrusion. With an array of multiple nozzles LIQTRA aims at an increase of productivity by factor 4.



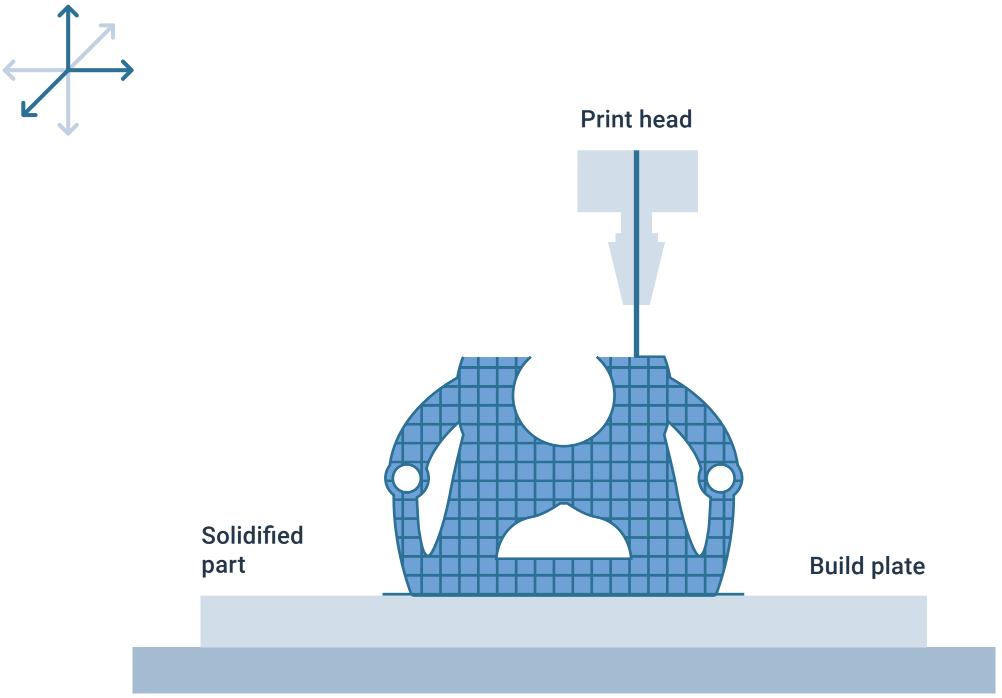
COURTESY OF LIQTRA

LIQTRA's novel Material Extrusion (ME) process utilizes a multi nozzle design to manufacture parts. While some providers in the ME market have already realized multi nozzle (parallel) printing, LIQTRA is following a different path. Their print head combines seven nozzles in one print head. Each nozzle is individually controllable. Depending on the printing path geometry LIQTRA extrudes with multiple nozzles at the same time, to generate the part geometry and reach up to 4 times the productivity of conventional single extrusion systems.

LIQTRA will present a first version ME multi nozzle system in fall 2022.

VOXELFILL by AIM3D

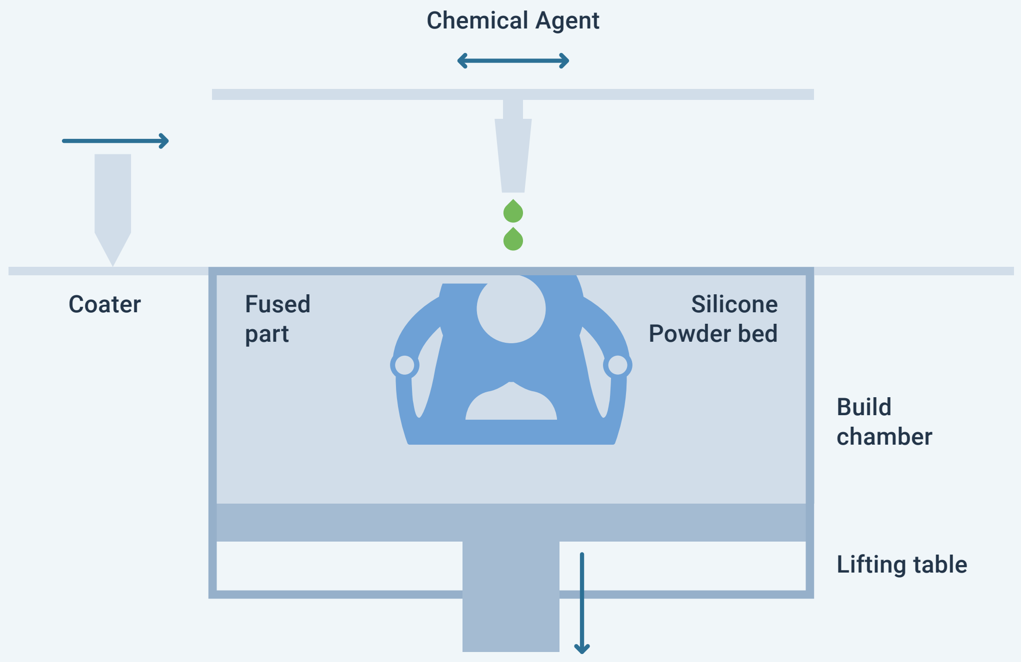
In the second half of 2022 AIM3D announced a process innovation called Voxelfill. The target is to reduce the effect of axis-dependent material properties in Material Extrusion components.



The Voxelfill process is an addition to their already established Pellet Material Extrusion process and was developed to enhance resulting material properties. Due to the intrinsic nature of today's Material Extrusion technology, mechanical properties are anisotropic. The Voxelfill approach is addressing this issue.
Pellet Material Extrusion is used to create a hollow base structure, similar to infill structures known from Filament Material Extrusion. After several layers, the printing head is placed on top of the individual cavities to fill them with molten material. Facilitating the extrusion head, this is realized at relatively high speeds and aims at creating axis-independent material properties for the filled volume units. Depending on the load, the voxels are filled or left empty to achieve an optimal balance between weight and component properties.
The top of the infill material is smoothed and the voids are sealed with several printed layers. This cycle is repeated until the last voxel is filled and finished with a cover structure.

Silicon Powder printing by ESI-PRINT

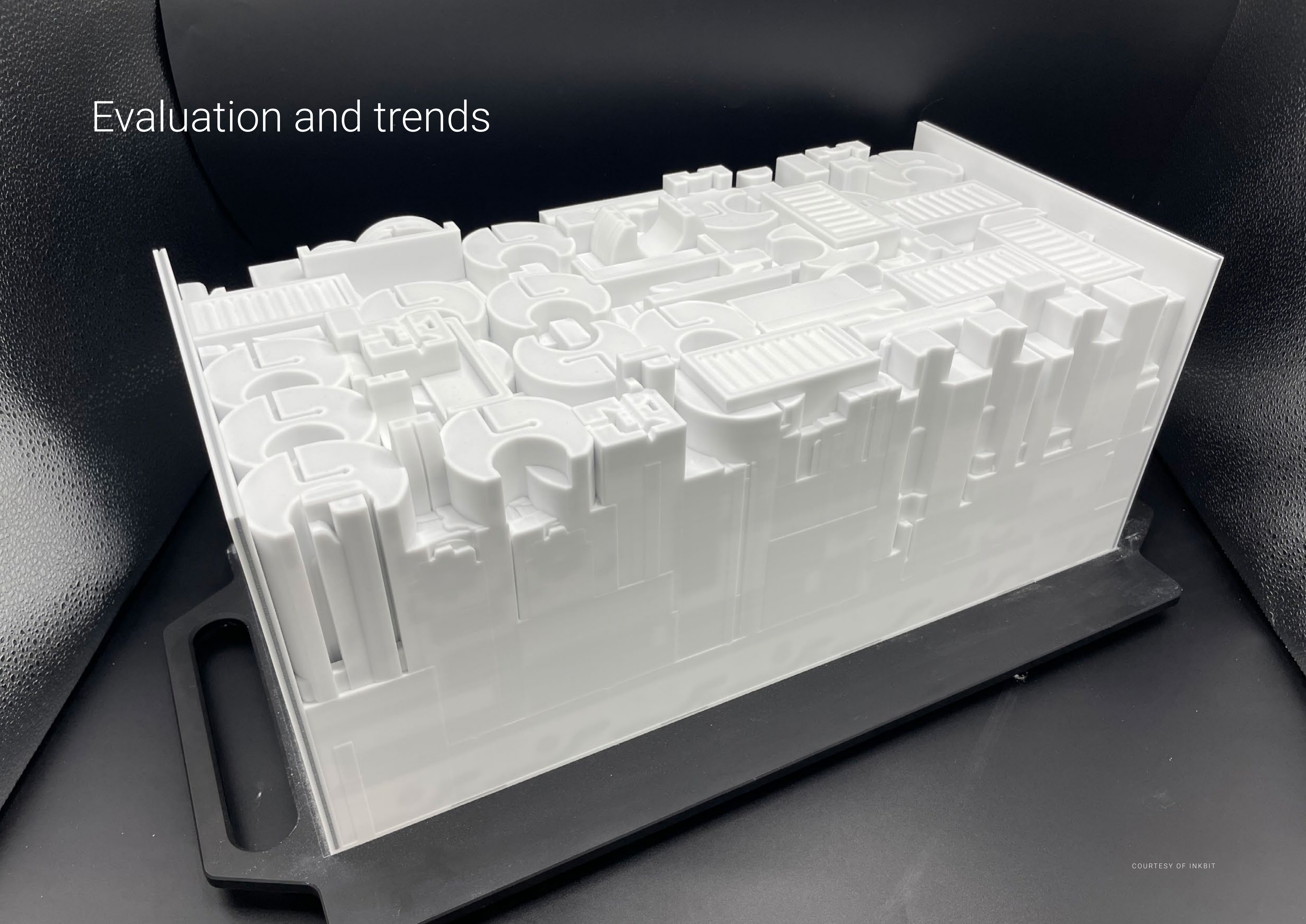
Thermal Powder Bed Fusion is one of the most advanced 3D printing processes and used across many industries for a multitude of industrial applications. The company ESI PRINT developed a technology to process elastic silicones.



ESI-PRINT was founded in early 2022. The developed technology is a powder-based process in which binder is selectively applied to a flat powder bed, in this case a silicone powder and a silicone oil as binder. The silicone oil initiates a chemical reaction to form a solid silicone part. As the component is supported by the powder during production, support-free overhangs and undercuts can be incorporated into the additive design.

COURTESY OF 3DEUS DYNAMICS

Evaluation and trends

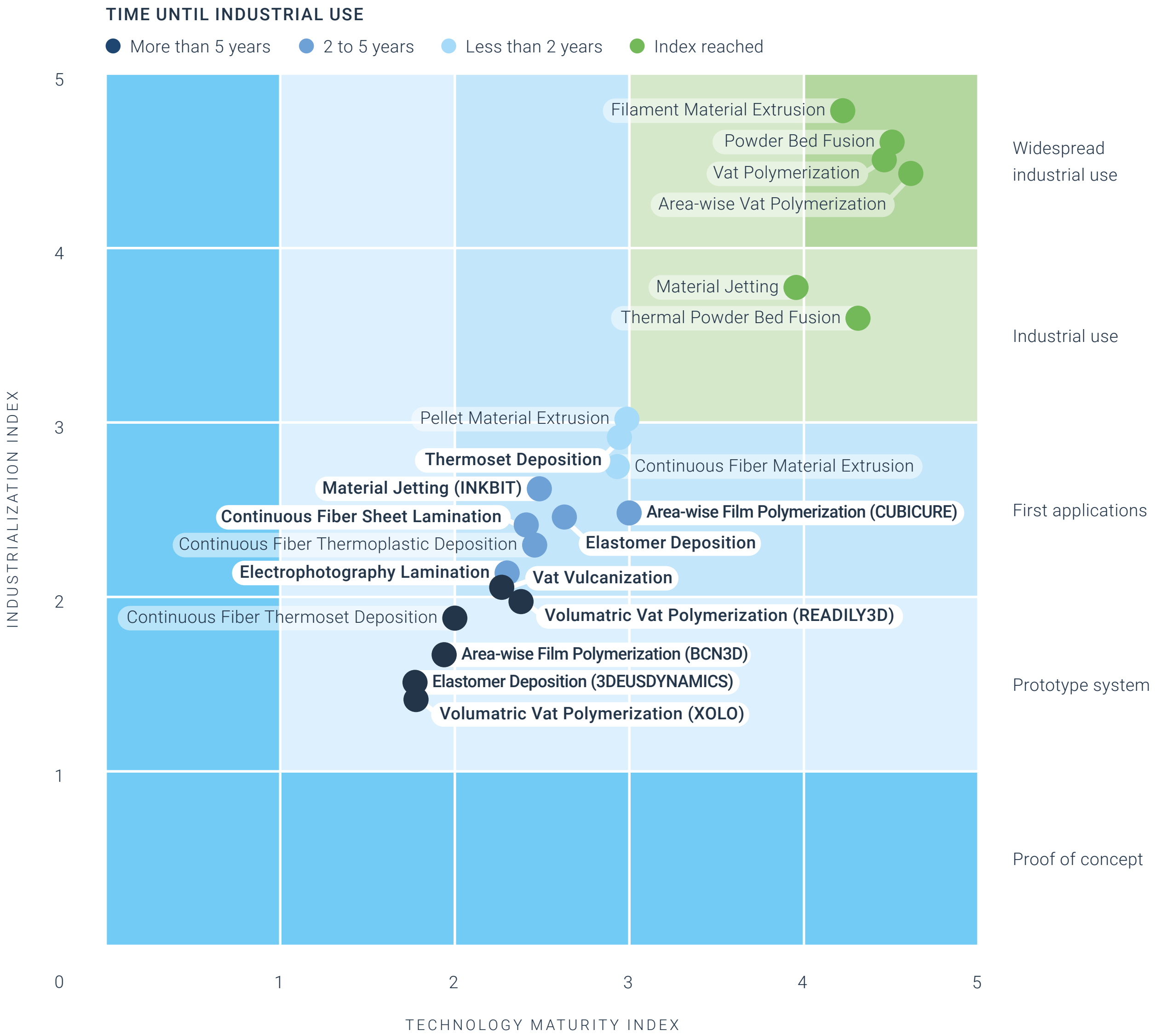


COURTESY OF INKBIT

Evaluation of new technologies

The new polymer AM technologies offer great potential for currently impossible or uneconomic applications and will drive further industrialization. Especially high throughput technologies like Area-wise Sheet Polymerization and Electrophotography Sheet Lamination are a chance to advance polymer AM to an industrial output level compared to injection molding. On the other side, AM production methods like Volumetric Vat Polymerization generate added value in specific industries such as medical and dental unreachable with conventional manufacturing technologies.

Maturity index of new AM technologies



Future AM mega trends

Industrialization

The Additive Manufacturing suppliers will have to fulfill the increasing requirements from industry that call for higher productivity at lower cost. Main competitor and benchmark technology for most AM technologies will be the injection molding process. While high volume production will most likely continue to be realized by injection molding, AM technologies will take their piece of the pie by reducing lead times and lowering material consumption. AM polymer technologies are already widely spread across most industries. AMPOWER expects that new technologies will increase the market share of Additive Manufacturing, if material prices become competitive and productivity of processes increase.

Material Development

Materials for Polymer Additive Manufacturing are often tailored to a certain process. This results in new AM specific materials that have no prior industrial relevance. For future growth the industry needs more relatable materials, or alternatively has to understood the properties of these AM specific materials. With regards to the diverse market of thermoset liquid materials, a more transparent communication of material composition and mechanical properties would help the industry to gain trust in the technologies.

Sustainability

A major concern of our time is the consideration of finite natural resources that call for efficient processes. Polymer Additive Manufacturing can play a major role in improving the environmental footprint of a production process by reduction of waste, but also in improving the resource footprint over the complete part life-time by providing individually optimized high-performance parts.

About the authors

Timo Führer

Timo joined the AMPOWER team in 2020. With a Master of science in the field of production technology and management he combines profound engineering know how with an eye for economic correlations. In former affiliations he has been intensively involved in Additive Manufacturing and worked on numerous projects in research and consulting. At AMPOWER Timo is leading the market and technology analysis as well as consulting projects involving polymer based Additive Manufacturing.

Dr.-Ing. Eric Wycisk

Since 2008 Eric successfully supports OEMs from aerospace, medical and automotive to identify Additive Manufacturing applications and implement production capacities in their regulated environments. With a background in topology optimization, titanium alloys and fatigue he is focused on achieving the maximum part performance with the right AM technology. As Managing Partner at AMPOWER, Eric focuses on technology evaluation and benchmarking, AM material and part properties as well as sustainability.

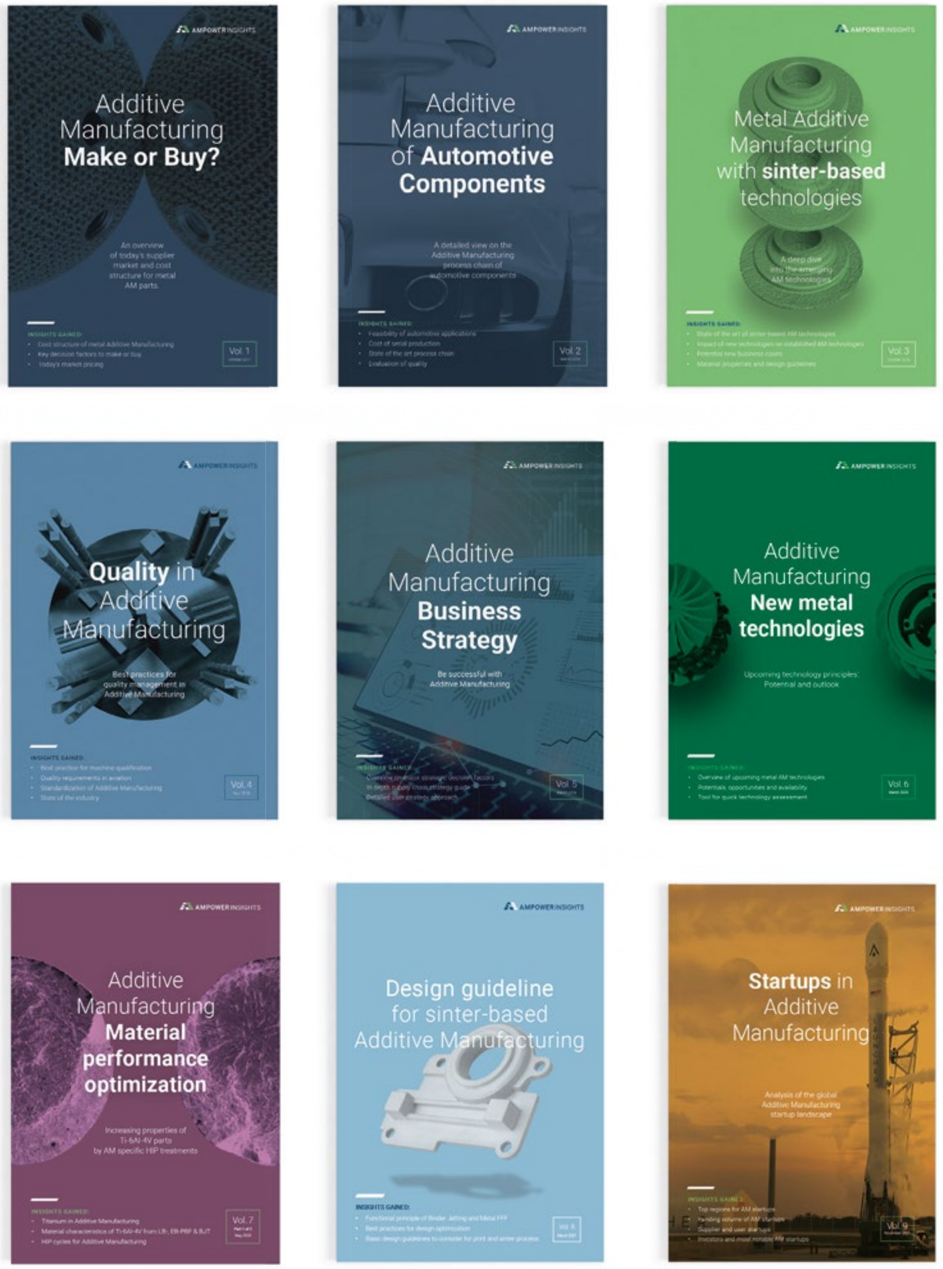
Matthias Schmidt-Lehr

Matthias successfully led multiple projects in Additive Manufacturing with focus on business case and strategic development for AM users as well as system and material supplier. With a history in management consulting he has a wide experience in business development, strategy development and communication. At AMPOWER he led multiple projects concerning DED, BJT and Metal FDM as well as a wide range of polymer AM technologies.

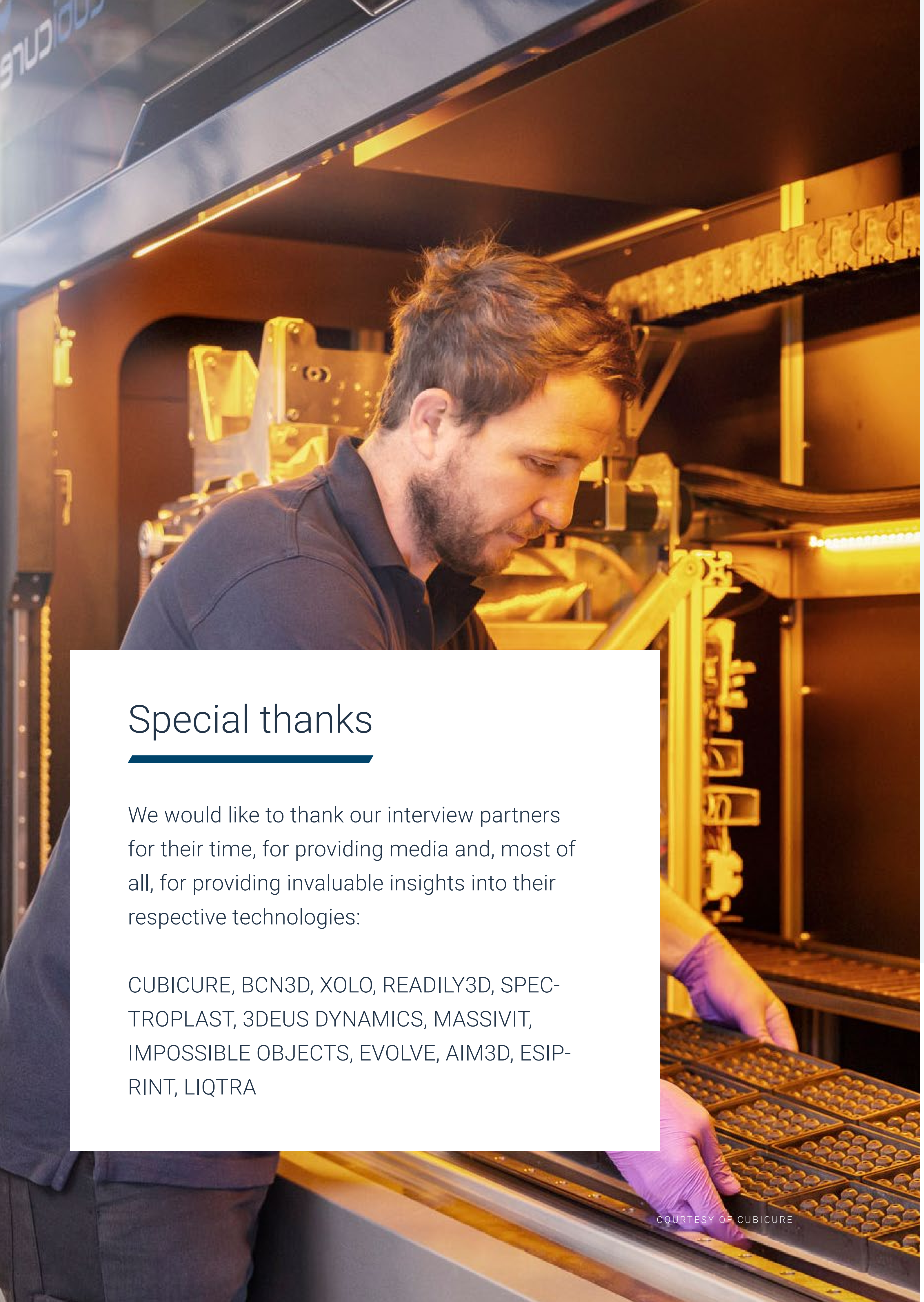
Dr.-Ing. Maximilian Munsch

Maximilian is a professional user of Additive Manufacturing since 2007. After finishing his dissertation on reduction of residual stresses in metal Additive Manufacturing in 2012, he acquired extensive hands-on experience with different Powder Bed Fusion processes in regulated industry before co-founding AMPOWER in 2017. As Managing Partner at AMPOWER, Max focuses on data analysis, market intelligence and due diligence investigations.

Missed out on our previous issues?



Download **AMPOWER Insights Vol. 1–10** at
www.ampower.eu/insights



COURTESY OF CUBICURE

Special thanks

We would like to thank our interview partners for their time, for providing media and, most of all, for providing invaluable insights into their respective technologies:

CUBICURE, BCN3D, XOLO, READILY3D, SPECTROPLAST, 3DEUS DYNAMICS, MASSIVIT, IMPOSSIBLE OBJECTS, EVOLVE, AIM3D, ESIPRINT, LIQTRA

Corporate responsibility

Since 2019 AMPOWER compensates all CO2 emission produced by its daily operation, travel activities and digital data storage. By using ATMOSFAIR, a verified non-profit organization, to offset our carbon footprint we are actively supporting renewable energy and emission reduction projects in developing countries.

This AMPOWER Insights is printed on 100% recycled paper.

AMPOWER

AMPOWER GmbH & Co. KG
Alstertor 13
20095 Hamburg
Germany

+49 (0) 40 99999 578
info@ampower.eu

www.ampower.eu