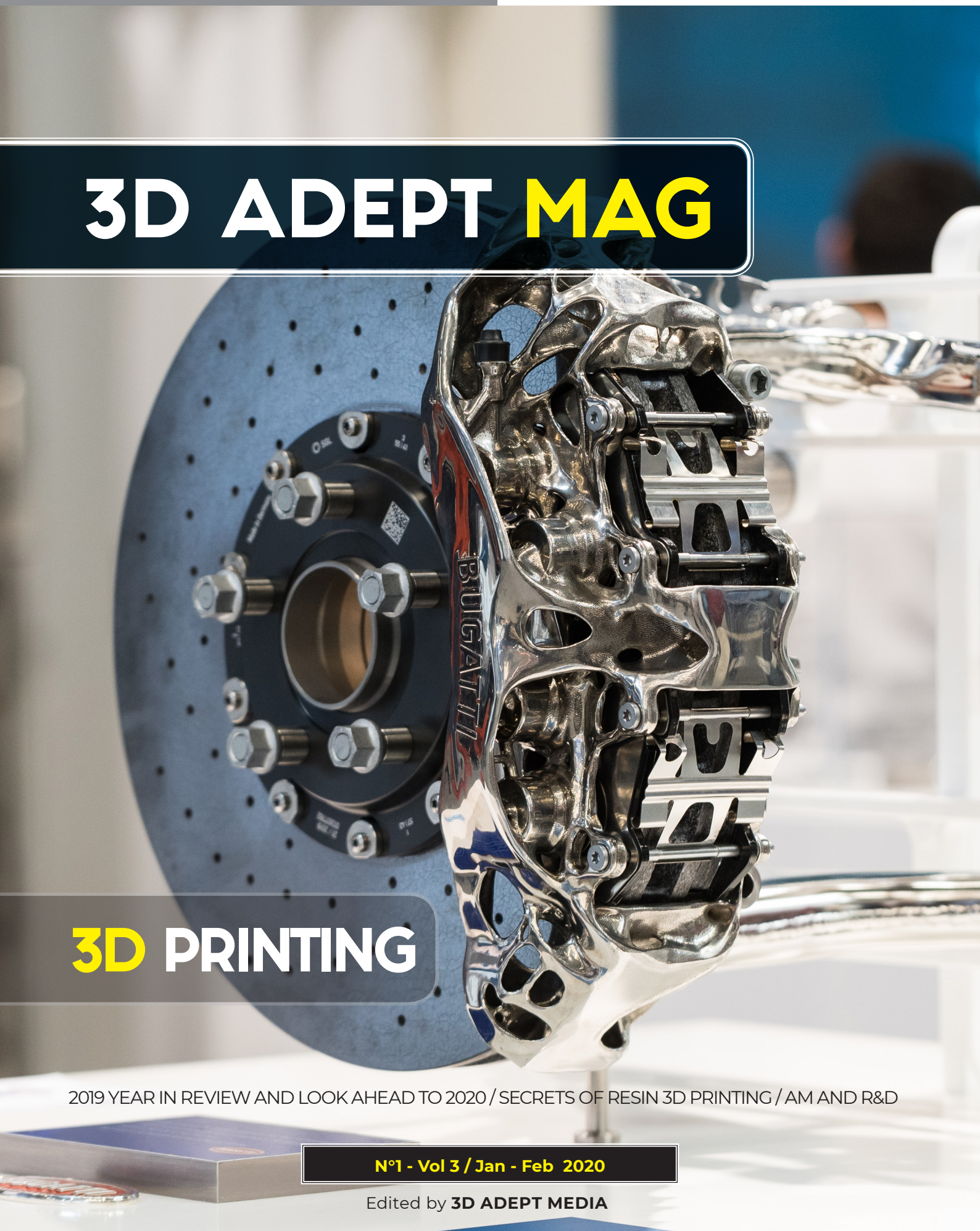
MANUFACTURING additive

3D ADEPT MAG



3D PRINTING

2019 YEAR IN REVIEW AND LOOK AHEAD TO 2020 / SECRETS OF RESIN 3D PRINTING / AM AND R&D

N°1 - Vol 3 / Jan - Feb 2020

Edited by **3D ADEPT MEDIA**

3D Adept Mag

ADDITIVE MANUFACTURING/ RAPID PROTOTYPING/ TECHNOLOGICAL INNOVATIONS

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Editorial

We all share one wish. Achieve our dreams.

It is not necessary to have decades of experience, to realize that in this industry, ordinary is obsolete. Most engineers reading this magazine, dream of changing the world with something that was never done before. The New Year reminds them what they have already done or what they did not yet do, and what they aspire to achieve.

I truly believe the end of a year or the beginning of a new one does not have to be the time for this thinking. This reflection could be done on February, April, June, August, October or just now, when you feel you are ready, when you realize the risk of trying something new is actually much lower than the cost of desperately clinging to what's worked in the past. I believe that's the fuel of any disruptive idea.

Well, 2020 is here. The end of a decade for some people, the beginning of another one for others. Whatever it is for you, for the first time, I feel that the "best wishes" tradition has become "ordinary" to me. So, I won't make it in this editorial. I would rather encourage those who already know the "fuel of disruption", to keep embracing it, to push innovation forward. To those who know that drive, yet are still trying to make their idea work, well, try harder. To those who are still hesitating, to them, I say, feel the fear and take action anyway. And to those for whom this path is not a vocation, be aware of what you are meant to be, of what you want to do and do it well.

In the end, we all share one wish. Achieve our dreams.

Kety SINDZE

Contents

N°1 - Vol 3 / Jan - Feb 2020

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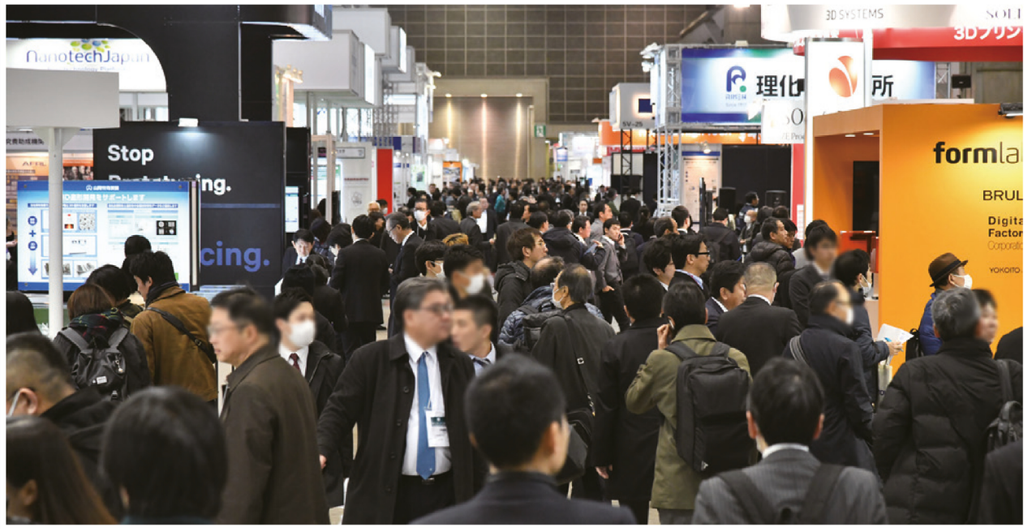
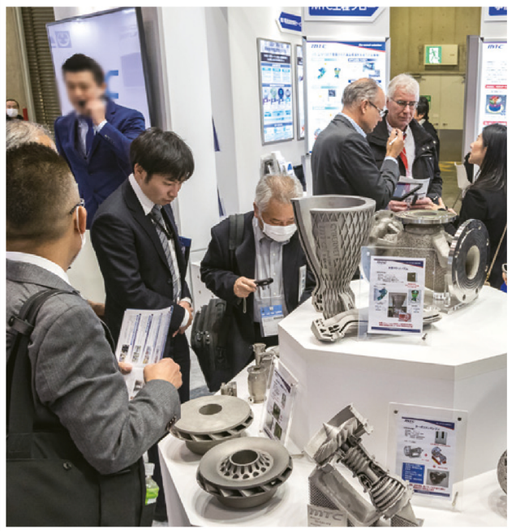
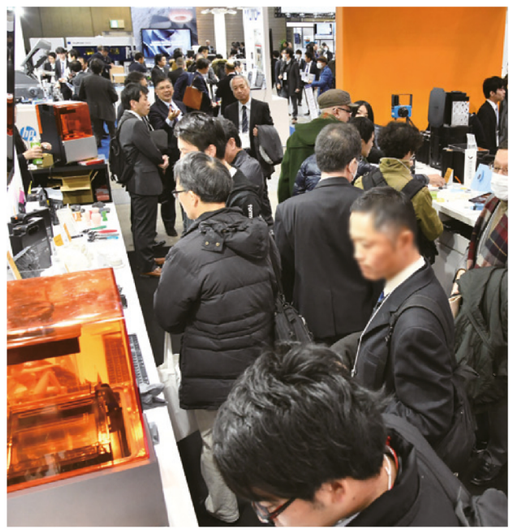






150 exhibitors **200** booths

50,000 attendees From **20** countries

Additive Manufacturing

2019 Year in Review and Look Ahead to 2020

Throwback to the biggest event of 2019: Formnext

When we look at the number of decades it took to manufacturers to acknowledge additive manufacturing as a serious manufacturing process, we would have never imagined that this technique of fabrication and its related technologies would have created such a euphoria in the industry.

We are very far away from the feelings of hesitation companies and users had five years ago, when Mesago first opened the doors of Formnext. From a single Hall 3 in 2015 to 4 halls, 852 visitors and over 34 000 visitors in 2019, Formnext has established itself, as one of a kind event in the entire world.

What does it mean to be part of this AM world?

Whoever tries to compare the previous years and this 2019 edition will agree with this simple fact: it feels good to be and to get into AM now. AM is growing exponentially and it will certainly continue to grow over the upcoming years.

If this growth percentage reflects on the one hand, the broad range of developments across the sub-sectors of the AM/3D printing technologies: hardware, software, materials, services and post-processing, on the other hand, the introduction of new companies and AM business units into the market, for Formnext, it means creating an environment that everyone will recognize as the premiere event for exhibiting additive manufacturing technologies; in a nutshell, the place to be to take AM one step further.

In this vein, this article does not aim to spread the individual launches that occurred last week – as a matter of fact, it would have simply be impossible to do in one single article -, but rather to unveil the main trends and impressions that have been observed during this fifth edition of Formnext.

Being part of the AM world means a lot to several stakeholders and in different ways:

For the new wave of newcomers

Providing a product or service to the AM world is one thing, dedicating a new company or a complete business unit to an AM activity is showing the industry you are one step ahead. This year at Formnext, several companies made their official entrance into the AM industry: **Xerox**, the brand "AM Solutions" of Rösler, Meta Additive, One Click Metal, Tritone, 6K, and many more…

Apart from those who supply 3D printing services, this new wave of newcomers comes with one goal in mind: to enable industrialization of AM, a long-term vision that is shared by existing AM companies.

Both groups, newcomers and existing leading companies, whether there are software editors, material specialists, 3D printer manufacturers are working on various areas for improvements that consist in enhancing throughput in terms of repeatability, reproducibility and traceability as well as increasing part volume throughputs.

The growth of Formnext is also marked by the development of activities that were given second-rate treatment

One reason why Formnext has reached new heights is because, operators are increasingly realized the importance of the full lifecycle of 3D printing/AM. The production does not start by 3D printing and does not end at the end of the 3D printing process.

As a matter of fact, the post-processing stage is often the most expensive part of the process and the stage that is often given second rate treatment.

Formnext revealed an increasing number of post-processing systems, services and interestingly networks dedicated to support AM operators during and after the printing process. Furthermore, some exhibiting companies simply displayed non-3D printing workload optimizations to show manufacturers the various options they have at the end of the manufacturing. A few companies that specialize in this increasing sub-sector include the **AMP+ network, Additive Manufacturing Technologies (AMT) Ltd, AMPRO, Rösler, PostProcess, 3DWash, DyeMansion** and many more.

The rise of specific sectors of activity

The AM world also comprises specific verticals that aim to address challenges of specific industries. In this vein, medical 3D printing companies such as 3DSide, Kumovis, were particularly well represented at Formnext. Furthermore, we also note the increasing interest of machine tools companies in AM. Apart from leading companies like Trumpf and DMG Mori, we also note the presence of other giants of the conventional manufacturing technologies like Ermaksan that unveiled its latest metal AM technology.

Addressing specific challenges

Contributing to the advancement of the AM world inevitably requires to address the challenges faced by the industry.

A number of companies at Formnext addressed the challenges raised by pure copper. **GE, EOS, Spee3D, Optomec** and **Farsoon** brought pure copper AM solutions at Frankfurt.

In the same vein, addressing sustainability is still nascent but it is already the concern of several companies that showcased products specifically designed to be biocompatible and/or eco-friendly.

The sense of belonging to a community

We often tend to forget it, but behind these companies, stand a wide range of teams that are doing their best efforts to make this industry work. And Formnext is also the place to celebrate this willingness and this community.

« What did 2019 mean for AM companies and what are they looking forward to in 2020? »

At the beginning of 2019, we asked additive manufacturing experts what were their predictions for the year. The main forecast for participating companies was to focus on education, and how to move AM to production.

Another trend was to focus on the development of new materials. Although, we witnessed some encouraging partnerships between material suppliers and 3D printer manufacturers, it should be noted that there is still a supply/demand imbalance on the market.

Nevertheless, 2019 has been very exciting as it showed various deployment strategies to help the industry move forward. Things were not always easy, as sometimes, the uncertain political climate in some regions was not conducive to business. However, most companies showed optimistic results with regards to their goals while others decided to take a different direction in order to be more efficient.

At the end of the year, we reached out to 21 companies to discover what exactly 2019 meant for them, and more importantly, how they envision 2020. These companies include 3D printer manufacturers, material suppliers, contract manufacturers/3D Printing service bureaus and software publishers. They share their vision below.

Looking Back at 2019 and Forward to 2020

SOLVAY

«2019 has been a year of deployment of Solvay's AM strategy, with several partnerships with printer manufacturers, the broadening of our product portfolio, and the deepening of our ecosystem along the entire AM value chain. This strategy is aligning well with the move of many end-user industries from hype to real projects. We expect this trend to continue and accelerate in 2020, with more news to come from Solvay, supporting our ambition to become the leading supplier of AM-ready high-performance material solutions.»

Christophe Schramm, Manager of New Technologies for Solvay's Specialty Polymers global business unit, material supplier.

Jon Donner CEO of Nanofabrica, specialist in nano-3D Printing

«2019 was packed with exciting achievements at Nanofabrica. We sent dozens of parts to global customers including Fortune 500 companies. Recipients were highly impressed with the results and with the level of accuracy we reached. Later in the year we finalized our industrial machine which offers an impressive build volume of 50x50x100mm, won a TCT award for it, and signed our first Beta sales. in 2019, Gartner published their forecast for emerging technologies, and stated that nanoscale 3D printing technologies were on the rise. In 2019, we were able to witness this at different conferences and exhibitions across the world. In 2020 we will see for ourselves the real need for this technology. The market asks for it, and we're here to deliver.»

NANOFABRICA

Phil Schultz, EVP, Operations, 3D Systems, provider of a comprehensive range of products and services, including 3D printers, print materials, software, and on-demand manufacturing services

3D SYSTEMS

"In 2019, 3D Systems realized a number of key milestones, the most prominent being that 3D production is no longer a goal, but reality. We've seen evidence in the most recent E&Y study that confirms the adoption of additive is ramping – moving from the researching and prototyping phase to production – with nearly 75% of companies embracing the technology. As a company, we continue to put the customer at the center of everything we do – and our customers have been a key element of how we've brought production AM to life. We've collaborated closely to first understand the application each customer is addressing, and then where we can add value in their respective workflow. In many cases, our customers' needs for production workflows have been the catalyst for our innovation, which is exactly what happened with the newest materials we've launched. In the last four months of the year, the majority of our 10 new materials were designed for production applications. By the end of 2019, 3D Systems' application-specific production solutions will yield approximately 200 million end-use production parts – an unprecedented industry first.

As the integration of our technology into customer workflows continues to accelerate in 2020, so too will the number of manufacturers 3D printing plastic and metal end-use parts for applications in healthcare, aerospace, automotive, dental and consumer goods. 3D printing will transform how companies create new, improved products while gaining efficiencies that place them well ahead of their competitors."

3YOURMIND

In 2019, 3YOURMIND added their first customer focused primarily on serial additive manufacturing: Erpro Group. We have seen our other customers also validate many small and large series AM parts that will move into production in 2020. We were happy to enable this with our Part Identification, Order- and Production Management Software.

As we expand our features to manage these new use cases, we are coming much closer to full automation. The work we began with umati in 2019 to establish machine connectivity is also a significant step towards this goal of a fully digital AM workflow.

We know our customers will be putting many more parts into production in 2020 and 2021 - so we will focus on digitizing and tracking the production and documentation processes in the Agile MES even better. With our Agile PLM we will help customers to identify many more positive use-cases and store them in a digital inventory, so that they are ready to be ordered on demand.

Stephan Kühr, CEO, 3YOURMIND, 3D printing software company

"SLM Solutions reflects back on 2019 and describe it as a resetting year. We announced that our order grew by 21% YoY and doubled in Q4. The confidence that customers and the partners put in our products and in our company is impressive. This is demonstrated not only by the growth in the orders but also by numerous successful projects and partnerships throughout the year – whether the recently announced letter of intent to expand cooperation developing the next generation machine with Divergent3D, the Honeywell announcement on 90micron parameter development, the collaboration with Bugatti to realize functional components or the use of Selective Laser technology in race cycling from the Danish Institute of Technology and CeramicSpeed. SLM Solutions presented these and many other exciting projects at the leading trade fair for additive manufacturing; Formnext, which turned out to be another highlight of 2019. The large number of trade visitors showed great interest in SLM® Multi-laser technology, and the trade fair appearance was crowned by several sales deals and partnerships that were signed.

Meddah Hadjar, CEO of SLM Solutions, manufacturer of 3D metal printers

For 2020, we will continue to make progress in the marketplace. We will work with our customers on increasing additive adoption and SLM Solutions is well positioned to lead in the laser powder bed fusion. As the pioneers of multi-laser powder bed fusion, our expertise in productive, reliable machines will continue to provide production solutions for a range of users. Looking to the future, we will be working on further advancing the technologies highlighted as future technologies at our booth to make them available to customers as industrialized solutions that will give an entirely new perspective to the concept of productivity in metal additive manufacturing. SLM Solutions heads into 2020 with focus on industrialization of our machines, productivity, and process parameters."

SLM SOLUTIONS

"With our commitment to offer truly open and high-performance additive systems to industrial AM users, Farsoon achieved significant machine sales growth in 2019. Farsoon was able to expand its footprint in a variety of additive applications including aerospace, automotive and the prototyping industries. With continuous technology innovation, Farsoon is able to offer differentiated systems to the market, including HT1001P, FS421M, Flight Technology and the latest FS301M.

In 2020, Farsoon will focus on additive innovation and industrialization --- working closely with global industrial customers to share and grow our know-how in material, additive technology, and applications with a goal to transform Farsoon's innovation into true manufacturing reality."

FARSOON TECHNOLOGIES


Jack Cheng, DGM, Head of Global Sales & Marketing of Farsoon Technologies, Industrial 3D Printer Manufacturer

Edited by 3D ADEPT MEDIA

Here at PostProcess, in 2019 we saw our customers' volumes grow significantly, particularly at companies that rely on fast innovation to drive growth, such as those leveraging 3D printing for fast prototyping. We also noted a heightened interest by more companies considering additive manufacturing for low volume production. With these trends of volumes increasing, 2020 will bring an accelerated need for scalable solutions for the post-printing step. The legacy approach of completing post-printing with manual labor and traditional mechanical solutions will no longer be practical options for production scale applications looking to connect the end-to-end digital thread. Additionally, in 2019, the market continued to expand its materials offerings and enable more complex geometries. This is also exciting as PostProcess expands our offerings in 2020 to enhance our fully automated, data-driven solutions to help end-users achieve increased throughput and consistency of their final parts.


Bruno Bourguet, Managing Director, PostProcess Technologies International

POSTPROCESS
Automated. Intelligent. Comprehensive.

XYZ PRINTING

FERNANDO HERNANDEZ
MD EMEA at XYZprinting, 3D printer manufacturer

"2019 was certainly a memorable one for XYZprinting. It's the year we have launched our Industrial range of devices, consolidating the offer in technologies such as SLS, Binder Jetting and SLA/DLP. But we didn't stop, also we've seen the announcement of multiple new industrial printers that are some of our most innovative products to date, such as the PartPro120 xP delivering speeds that are up to 75 times faster than conventional 3D printers without sacrificing printing quality or resolution, thanks to XYZprinting's Ultra-Fast Film technology. With almost every vertical solution and service to offer, we've continued to stand out as a market leader in desktop, retail, education, and luxury item printing, and building on our presence in professional printing too. Going ahead, we will set our sights on further carving our mark on the automotive, medical and architecture industries too.

Looking ahead, 3D printing will be advanced forward by the volume and quality of new materials, something XYZprinting will help with by entering our own materials partnerships with popular third-party companies. Another key theme I anticipate for 2020 will be a shift in perception of how 3D printing can in fact complement traditional manufacturing as opposed to being in competition with it. Adding to this, 2020 will also see the 3D printing industry leverage the latest software to improve supply chains leading to superior quality outcomes. One thing is certain, the forecast for 2020 is bright."

JABIL

JOHN DULCHINOS
VP, Digital Manufacturing for Jabil Additive, manufacturing services company

"2019 was a year of continued growth for Jabil Additive as the organization took advantage of its rich history in materials science innovation to accelerate the development of custom materials and advance the entire additive manufacturing market forward. Jabil forecasts continued momentum in 2020, especially the growth of integrated solutions featuring engineered materials, rigorous processes and certified 3D printing machines to support applications for highly regulated industries, such as aerospace, automotive, industrial and healthcare, as well as those requiring optimized geometries or consolidated bills of material (BOMs).

Jabil also projects an increase in certified additive manufacturing solutions built upon robust quality management systems that accelerate the use of distributed production networks to meet stringent part quality and performance demands. Additionally, Jabil anticipates an influx of new engineered materials with unique properties to enable new applications while reducing time-to-market and cost in bringing the highest quality parts to market. To that end, Jabil will continue to evaluate, qualify and validate a diverse mix of engineered materials for use with its interconnected Additive Manufacturing Network of world-class 3D printers and quality processes to provide a faster path from prototyping to full-scale production of disruptive products."

ARBURG

LUKAS PAWELCZYK
Head of Freeformer Sales, Arburg, manufacturers of injection molding machines & 3D Printers

"Additive manufacturing will continue to grow in significance in the field of medical technology, as demonstrated by a number of well-known Arburg Plastic Freeforming (APF) customers in 2019. They are now using our open system to process biocompatible, resorbable, sterilisable and FDA-approved original materials. I think that, in 2020, we will see implants being produced with the Freeformer in clean room environments and used in the human body.

For us as a machine manufacturer, quality assurance and process monitoring are also very important in the AM process. With the Freeformer and our comprehensive know-how in the field of plastics processing, we are able to automate the additive manufacturing process and record all of the relevant construction parameters via OPC/UA interfaces. It is becoming more and more important to ensure high quality standards when producing functional parts using additive manufacturing, and to document this process reliably.

Our main focus in 2020?

Think additive! As a machine manufacturer, we need to work with our customers to develop the areas of application for additive manufacturing and make the most of the new degrees of freedom in this field. We will also be focusing on topics such as resource conservation and sustainability, both here and in the injection moulding sector."

anisoprint

FEDOR ANTONOV
CEO at Anisoprint
3D Printer manufacturer

"For Anisoprint, 2019 was the year of conquering new territories: "anisoprinting" is now distributed in more than half of Europe with our entry-level product — desktop continuous fiber 3D printer Composer. We also look into the future of the technology: there will be even more possibilities for replacing metals or non-optimal composites with our new PrоM IS 500 — an industrial 3D printer specifically designed for printing high temperature thermoplastics with continuous fiber reinforcement.

In 2020, the AM industry will continue to look for better materials, approaches and applications to make additive manufacturing inventions competitive in comparison to traditional technologies. Anisoprint that integrates a team of researchers and engineers with extensive experience in composites will also contribute in this process: we'll continue to develop continuous fiber 3D printing that tends to become popular due to its advantages. Some of the biggest companies in the AM area have already understood that, and we're waiting for more in the coming years."

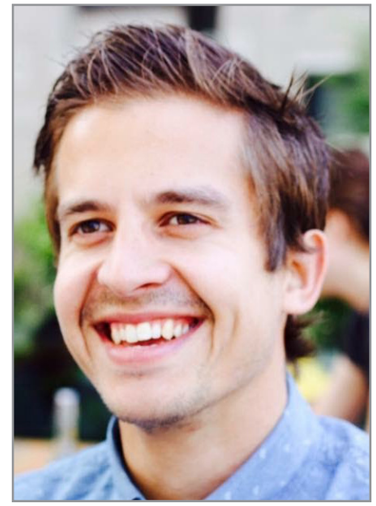
AMFG / Autonomous Manufacturing

KEYVAN KARIMI
Founder & CEO, AMFG, supplier of workflow automation software for additive manufacturing

"2019 was a tremendous year for AMFG, as we witnessed more companies recognising the role of MES software in establishing a scalable, automated and connected additive manufacturing workflow. In 2019, we significantly grew our customer base across industries including automotive, consumer and industrial goods, and opened an office in Germany as part of our company's expansion.

We're, therefore, extremely optimistic about the industry's growth in 2020. This year, we predict that AM will continue its shift from rapid prototyping to serial production, and that new and innovative end-use applications will be made possible with the technology. Additionally, MES software will play an even bigger role in 2020, as more companies invest in 3D printing and seek ways to optimise, automate and scale their operations.

This means that AMFG will continue to develop solutions focused on enabling companies to do just this. This includes initiatives such as enabling machine connectivity, which we began by announcing our partnership with EOS last November. We will also extend the capabilities of our production management and scheduling solutions and to enable further automation of the AM process. Through these initiatives, we aim to make serial production with AM a reality."



3D HUBS

FILEMON SCHOFFER
Co-founder and CCO of 3D Hubs, online manufacturing platform

"We've seen a real shift in 3D printing orders in 2019. More and more small to medium engineering businesses are taking advantage of the prototyping speed and geometric complexity 3D printing has to offer. This has had a significant impact on the adoption rate of 3D printing in the product development process (e.g. the speed and number of iterations), as well as in high-end applications, where the benefits of 3D printed complex parts, outweigh its cost (e.g. unparalleled strength to weight ratio performance in aerospace).

Because of this, access to virtually unlimited on-demand 3D printing capacity, as well as a wide breadth of technologies, these relatively small businesses have become globally competitive in hardware development. We expect the adoption rate of 3D printing keeps to accelerate over 2020, as more companies catch on to its huge potential.

At 3D Hubs, we're gearing up to support this increasing demand in 3D printing by adding ever-faster lead times, more material options, and other manufacturing services including CNC machining, injection molding, and sheet metal fabrication. The faster engineers can receive their prototypes and end-parts, the faster they can iterate and bring their products to market. 3D printing will continue to play a pivotal role in speeding up that process."

Andreas Hartmann, Co-founder & CEO/CTO of Solukon, specialist in end to end post-processing solutions for Additive Manufacturing

«2019 was a very successful year for Solukon. We have installed many systems and received great feedback from our customers. For example, Materials Solutions as a very forward-thinking company has installed its sixth large depowdering unit and we are very proud to supply technologically leading aerospace companies in USA and Europe.

We have also taken major steps in the growth of our company and co-founded AMP+ as a specialized powder solution network. And to top it all off, we won the TCT Award Postprocessing together with Siemens.

We are pleased that the AM industry is increasingly recognizing the need and value of our highly automated depowdering solutions to ensure safe and efficient production.

In 2019, the aerospace and energy industry again pushed AM forward with new lightweight and thermodynamic design. Here in particular, we were able to score points with our new depowdering algorithms for complex geometries.

We also see a great future for parts with large heights such as rocket-engines and will soon be offering a solutions for depwodering 1 metre parts.

Due to the positive experiences with the cooperation with Siemens, we are now again teaming with other highly specialized AM users in order to step up our experience and consistently advance our technologies.»

solukon

e-Xstream engineering

"In 2019, the additive manufacturing industry has been ramping up and has reached a maturity level where simulation plays a central role. Industry is not anymore only investigating topology optimization and fancy geometries but is now rising the right questions: can it be print? how can it be lightweight & strong? can I print right the first time? how can I manage all my data related to the materials, the builds, the powder microstructure, ... Those are the typical questions we have been answering in 2019 and we expect it will increase in 2020. We predict our additive manufacturing ecosystem will keep growing in 2020 adding more and more materials suppliers, OEM printers, printing bureau, and obviously end-users and support the industrialization of AM."

Guillaume Boisot, Head of Business Development, e-Xstream engineering, software company

Gauthier Wahu, Managing & Technical Director, CoreTechnologie France, software publisher

CORETECHNOLOGIE

"2019 marked the launch of our 4D_Additive software. Our first customers, from the automotive, aeronautics and medical industries, have been won over and the marketing prospects for 2020 are excellent. Our Texture workshop is acclaimed by the Design and Innovation teams for its ergonomics and printing quality.

In collaboration with our customers, our 2020 developments will focus on productivity and design innovations. This year, our teams will reinforce the technology of the Texture workshop by integrating colour management and plan to add the «Batch Nesting» function to 3D PartFinder. 4D_Additive will also be optimized for SLM technology.

Printed and sublimated colours to make you look good.

4D_Additive will transfer the colors from the texture to the model to be printed for a more coherent and more aesthetic rendering. Technically, the .OBJ output format will allow to transcribe both deformations and colors."

Tiago Brito e Faro, Head of Engineering at Adira, manufacturer of sheet metal working machinery

adira

"The Market Product Release of Adira's Large Metal Printer is set to the end of 2020. While actively searching to increase our beta testers network, we are also consolidating the strategic partnership relations we already have in place.

During the upcoming year we have narrowed down a few points that still need fine tunes, focused mainly in the usability of the equipment. These tunes will ultimately improve our final product UX and UI to all our Beta Testers / Customers."

"2019 meant for Roboze contributing to the continuous innovation in the 3D printing technology market. All the innovations Roboze showcased in 2019 address the needs of all those entrepreneurial realities aiming at increasing their productivity thanks to high temperature super polymers and composite materials for the production of finished parts with the highest precision.

We are in the middle of a Fourth Industrial Revolution, where Additive Manufacturing has a key role. The industry is changing quickly, and Roboze constantly analyses the global market's changes in order to meet the real needs of the final customers. One of the main goals for Roboze will be contributing to the development of those smart factories capable to benefit from the technological advantages resulting from the integration of machines, production processes and final products.

We are aware that manufacturers will increasingly rely on 3D Printing alongside CNC machining, another strong indicator of how essential additive manufacturing is becoming within the production processes.

Europe, United States and Asia are certainly the fastest growing regions where nowadays Additive Manufacturing is developing on a global level. That's where we are focusing our efforts to increase Roboze's business growth, especially in the United States. In 2020, our main goal will be to make Roboze 3D Printing solutions a key player in the Industry 4.0 progress by offering high performance materials suitable for Metal Replacement applications and the production of functional prototypes and finishes parts globally."

Alessio Lorusso, Founder & CEO of Roboze, 3D Printer manufacturer

Roboze

Joseph Crabtree, Founder & CEO, Additive Manufacturing Technologies (AMT), specialist in end to end post-processing solutions for Additive Manufacturing

«2019 has been a pivotal year for Additive Manufacturing Technologies (AMT) Ltd. Founded in 2017, we are now fully commercial, and today there are a growing number of OEMs worldwide that are using our safe, sustainable, and fully automated AM post-processing solutions. Post-processing is one of the key areas of focus as companies seek to integrate additive manufacturing into speedy and cost-efficient production cycles, and the demand is for fully automated solutions that significantly reduce cost-per-part. Our process enhances material characteristics as well as completely smoothing surfaces, and fits within our overall drive towards wholly connected, customized, end-to-end digital manufacturing systems. That is the area in which AMT is operating in order to bring practical industrial solutions to OEMs using AM as a production technology, and will be our continued focus through 2020.»

ADDITIVE MANUFACTURING TECHNOLOGIES

"In 2019, Materialise collaborated with its partners to advance AM technology on many crucial fronts – faster machines, new materials, and more finishing options. Today, we see all of these advances coming together to create an exciting climate of innovation that will spark entirely new applications that were unthinkable or unachievable before.

As we develop new products and technologies to help our customers create meaningful applications, sustainability needs to become top of mind. Already, AM provides companies with an instrument to manufacture in a more sustainable way – both socially and environmentally. However, that's simply not enough. Collectively, we need to develop initiatives to reduce energy consumption, to increase usage of recycled powder and to create the workplaces of the future. So, moving forward, the question is not: is AM a more sustainable manufacturing technology? The question becomes: what can we do to make AM more sustainable?"

Kristof Sehmke, Communication Manager, Materialise, Software company & 3D Printing Service bureau

materialise
innovators you can count on

«2019 was a pivotal year for FELIXprinters as the company established itself as a key player in the industrial additive manufacturing space, offering cost-effective but highly accurate AM platforms for prototyping and production applications. During 2019 we added two larger build area machines to our portfolio, the Pro L and Pro XL, which are now sold into various sectors of industry where the demand is for easy-to-use, accurate, repeatable, and price sensitive AM solutions. The company also has the capacity to customise solutions to specific customer applications, and this is unique in the lower cost industrially-oriented area of the AM market-place.

For 2020, we will continue to position our industrial AM solutions, and will also be promoting our new FELIX BIO machine, which is making waves in the highly dynamic area of 3D printing and biomedical applications.»

FELIX printers

Guillaume Feliksdal, Co-Founder of FELIXprinters, 3D Printer manufacturer

Global Leaders in Aluminum and Copper Alloy Powders for Additive Manufacturing

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About Kymera International:

With nine manufacturing sites in seven countries, Kymera International is a global leading producer and distributor of powders, pastes and granules of aluminum, aluminum alloys, copper, copper oxide, bronze, brass, tin and several specialty alloys.

kymerainternational.com

AVIMETAL PM

ISO 9001 ISO 13485:2016

Powder Solutions for Metal AM

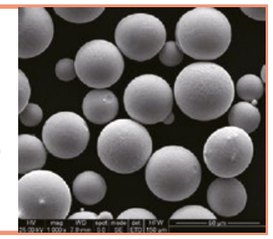
Main Powders

Titanium: Ti CP, Ti64 Gr5/Gr23, BT9, BT20, Ti6242, Ti4822, Ti2AlNb, NiTi50
Nickel: IN718, IN625, IN713, Hastelloy X, Hastelloy C276, Waspaloy
Cobalt: CoCrMoW, CoCrMo, CoCrW, HA 188
Stainless Steel: 316L, 17-4PH, 15-5PH
Die Steel: 1.2709(MS1), Corrax, H13, S136
Aluminium: AlSi10Mg, AlSi7Mg
Refractory Metal: W,Mo, Ta, Nb, Cr, Zr

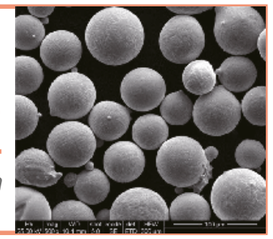
Additional alloys are available upon request

Advanced Atomization System for Metal Powder Production

Ti64 Gr5
15-45μm



IN718
15-45μm



Powder Characteristics	Capacity	Particle size range(min/max)
Controlled chemistry Spherical shape High flowability High apparent density High purity and applied to aircraft engine	Powder 600t/a Powder Atomization System 30units/a	0-20μm 15-45μm 15-53μm 20-63μm 45-106μm 53-150μm

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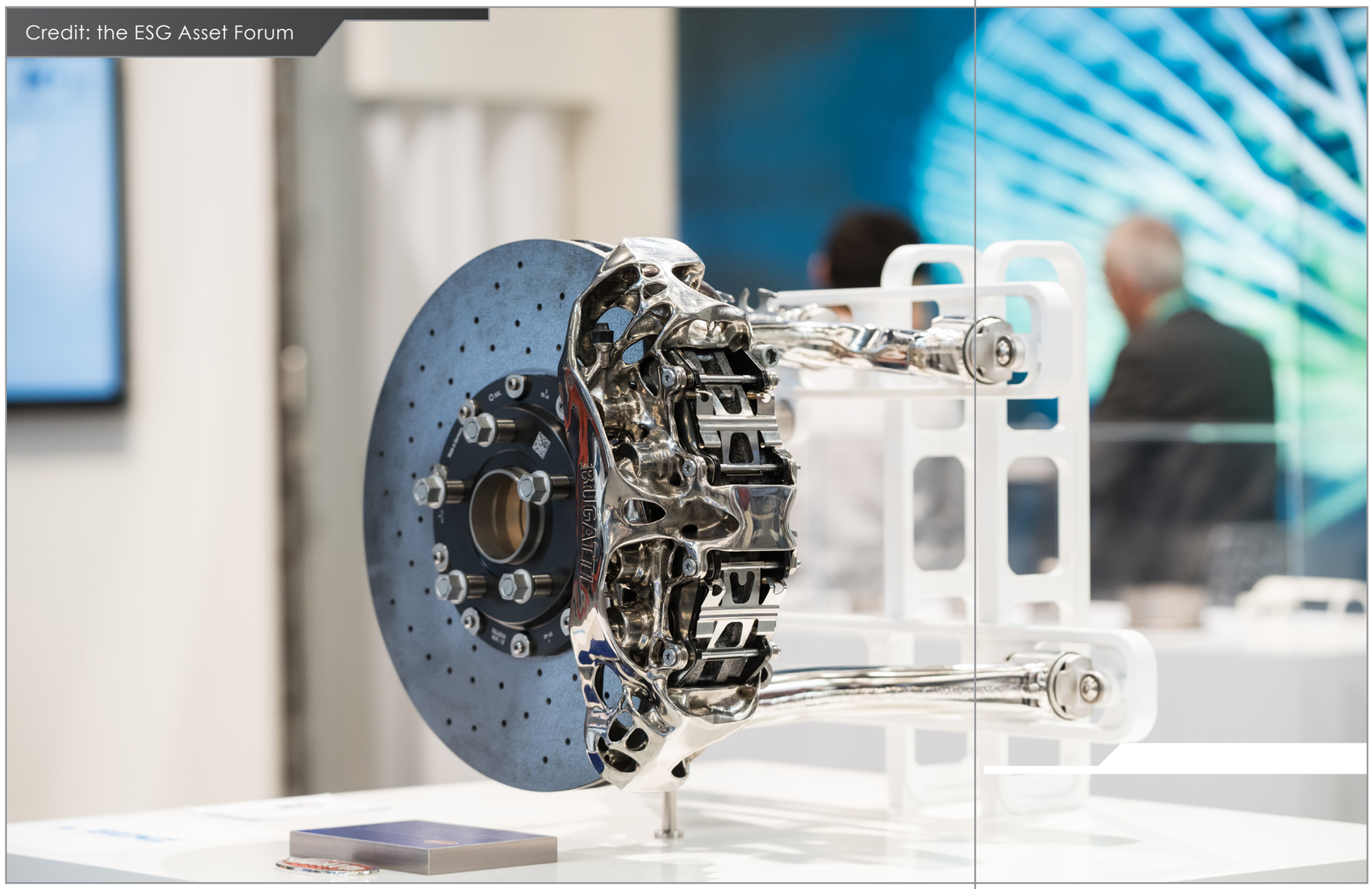
KEY TAKEAWAYS FROM THE YEAR 2019 :

The good, the bad and the areas for improvement

2019 was a lot of things at several levels: in terms of business, research & development and in terms of adoption of the technology in various sectors of activity.

Credit: the ESG Asset Forum



At the business level

The introduction of new companies / services dedicated to additive manufacturing

While some companies almost filed for bankruptcy, 2019 saw the introduction of several companies dedicated to additive manufacturing, and business units dedicated to additive manufacturing services. Among these companies, one notes the creation of Lincotek Additive & AM Solutions to name a few of them. Cytosurge's 3D Printing business unit named Exaddon & BCN3D for instance have become standalone companies. Others like CORE created larger AM companies through the acquisition of smaller businesses while Addilys & CeresiAM are part of newly-created companies that will offer the market a different solution. Meanwhile, other companies like Amastan opted for a rebranding to strengthen their position on the additive manufacturing market.

Lastly, the latest Formnext event also showed the official introduction of several new companies into the international arena and we will be able to know more about their offering in the upcoming year.

An increasing interest from investors in funding AM companies despite the small-number of funded companies

Surprisingly, compared to 2018, there was not a large number of companies that secured a fund-raising round. Well-established companies including Desktop Metal, Carbon, Markforged, Physna, Prellis Biologics or AMFG secured a financial round to further develop their business.

Only a small number of start-ups such as Spectroplast has been able to benefit from the support of investors.

Although this might look like the interest for AM is decreasing, it should be noted that well-established businesses are growing and AM start-ups are still making their mark in the AM industry. Furthermore, this shows that investors also need to be educated to additive manufacturing and its potential for industries, a mission that Wohlers has decided to undertake by discussing investment opportunities for AM.

When it comes to finances in this industry, when we do not talk about funding, we discuss acquisitions. And for some strange reason, among all the acquisitions that occurred this year, the acquisition of 3D Printing service provider Sculpteo by BASF left more than one speechless. Nobody expected that, yet Sculpteo is now a BASF company.

Announcing the installation of a new system in a facility is a milestone for a company, especially because, industrial 3D printing systems might require several months or years of negotiation before getting a purchase confirmation.

This year again, the metal AM segment stands out from the crowd. GE Additive, HP, SLM Solutions, Additive Industries, VELO3D & Desktop Metal are part of the companies that announced a big number of machines sold.

Others distinguished themselves from their fellow companies through interesting use cases. In fact, most manufacturers offer customers the possibility to take advantage of their AM technology for a given application. Titomic, Cobra Aero, Farsoon, Nexxt Spine, Admatec are a few examples of companies that showed what was possible with metal AM technology.

The rise of metal AM technologies also led to the development of post-processing solutions that were given second-rate treatment. This area of the AM industry will see a bigger evolution as companies have started to explore new forms of collaboration to raise awareness on the importance of these solutions.

An increasing number of metal AM technologies sold compared to other types of AM technologies

The polymer industrial 3D printing on the other hand, showed a great number of novelties at the materials level. Last year, experts predicted that a wide range of polymer materials will be developed to foster the adoption of polymer 3D printing. This end of year has proven this prediction to be true. Beyond the release of new polymer materials, we witnessed a great number of partnerships between polymer material producers and FDM 3D Printer manufacturers.

Lastly, as metals might not always be sufficiently lightweight enough, operators have started to explore the possibilities raised by composite 3D printing. With almost $250 million raised to date, companies like Markforged, Arevo, Impossible Objects, Fortify, Arris Composites, and recently Desktop Metal are a few examples of players that are transforming this niche market. This niche market increasingly raises investors' eyes and will certainly gain momentum in 2020.

Credit: Mesago / Mathias Kutt

"As metals might not always be sufficiently lightweight enough, operators have started to explore the possibilities raised by composite 3D printing."

Credit: Mesago / Mathias Kutt

The rise of 3D printing-dedicated events

The development of the industry led to the launch of several AM/3D Printing-dedicated events that all aim to raise awareness and educate on the potential of the technology.

Conferences across the world, in Saudi Arabia, in the Netherlands, in Spain and in the USA took place for the first time in 2019. These conferences shed light on AM applications and opportunities to seize within these regions.

New initiatives and the willingness to address the future's challenges

Sustainability remains a key issue for industry experts. As we will see below, some segments of the industry are already addressing this issue while specialists in other segments are still looking for ways to tackle it. One solution that has recently been launched in that sense is AMGTA.

At the Research & Development Level

Throughout 2019, we witnessed an increasing number of research centers leverage AM technologies. The increasing number of applications does not only demonstrate that this target becomes an interesting segment for manufacturers, it also shows the countless possibilities of the different ways to use the technology.

However, among the array of innovations explored, the most interesting ones remain the ones that deal with vital sectors like the medical industry.

Adoption of AM technologies

At 3D ADEPT, we've tracked the adoption of additive manufacturing technologies in numerous sectors including automotive, aerospace, medical, architecture, art, food, hi-tech & sport, fashion, oil, energy & gas industries, rail industry as well as education.

The automotive & aerospace industries as well as the medical industry undoubtedly remain the sectors that have showcased the biggest number of applications. It goes without saying that, these sectors have contributed to the development of the additive manufacturing industry, but also to the development of industry 4.0 technologies.

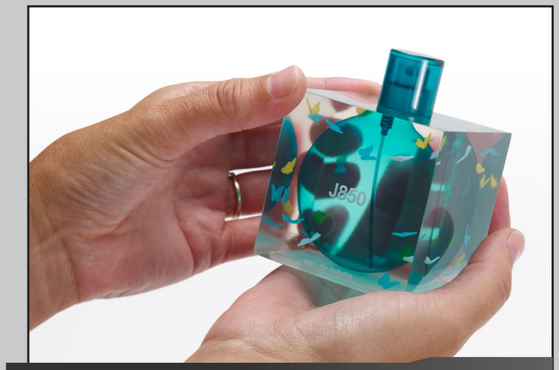


Image Credit: Sratasys – 3D printed perfume bottle on the J850 printer

However, while looking at the sectors we do not often hear a lot, we realized that experts are currently bringing an invaluable contribution to today's and tomorrow's world:

Last year for instance, the rail industry was said to be a nascent segment. This year, we've seen several applications of 3D Printed parts that have started to be used in trains on the one hand, on the other hand, new initiatives are designed to foster the adoption of AM by operators that ensure trains maintenance. Interestingly, the effective use of 3D printed parts in trains is not a small deal as it also requires that the 3D printed parts meet the regulatory requirements/ standards of the country in which the trains operate.

Furthermore, while in the art & fashion industries, 3D Printing enables to highlight artists' creativity, it should be noted that most of the products are often available in limited quantity. With the ability to produce a tailor-made 3D printed product, we believe mass production has certainly become obsolete for manufacturers that leverage AM technologies.

Image credit: Stratasys

One thing that left us speechless in the architecture & construction industries is the set of ideas that is being explored to enable life on Mars, to fight terrorism or to repair cracks on earth.

In the food industry, the use of 3D Printing has gone beyond the simple purpose of decoration. We believe that in 2020, this segment will witness an increasing use of food 3D printers in homes. Indeed, companies have explored the use of food 3D printers to produce vitamins, a more sustainable and affordable meat, or even 3D Printed snacks from food waste. In general, food 3D Printing users are already addressing sustainability issues that experts from the other segments are trying to address.

Lastly, education. At all levels, programs are being set up to give professionals, students and kids more skills in AM/3D Printing. This has been a great trend in 2019 and it will still be a big one in 2020.

To sum up, 2019 has been an exciting year for the industry. At almost all levels, experts gave us hope that industries are ready for something better. However, despite the wide range of applications unveiled, AM technologies still raise an array of concerns for most operators, so the real question would be to know when exactly they will be ready to make this leap.

The Secrets of Resin 3D Printing

Credit: eSUN

With the contribution of XYZprinting

Apart from FDM and metal 3D Printing technologies, resin 3D Printing remains one of the most widely used techniques for producing high-quality 3D prints. The recent years have seen the development of several types of resin 3D printing technologies as well as the launch of several cheap resin 3D printers raising several questions regarding its value in the professional sphere and the way it should be leveraged.

What is really resin 3D printing? When does it make sense to go for a resin 3D printing technology? Is resin eco-friendly or poisonous? – We will address these questions in the following lines.

When speaking about resin 3D printing, the first technology that comes to people's mind is stereolithography and for good reason: the printing process was first invented in the 1980's.

It was one of the first 3D printing technologies that professionals used on the market. A few years later, the other processes, DLP and LCD, emerged and became an additional option in the user portfolio.

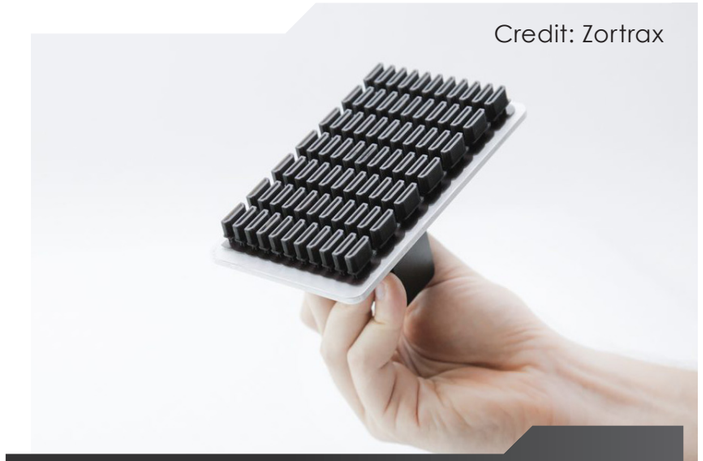
In general, resin 3D printing is about converting a liquid plastic into solid objects. However, understanding the principle of SLA helps to understand the main differences between the three processes.

So, SLA works by curing resin with light. The light solidifies a liquid resin via a process called photo-polymerization and builds objects layer by layer. A vat or tank contains the resin which is cured against a build platform. It thereafter slowly rises out of the tank as the object is formed.

With a digital light processing (DLP) technology on the other hand, a digital light projector cures photo-reactive polymers. Images of whole layers are flashed onto the bottom of the vat. Layers generated using DLP 3D printers are made up of voxels, the 3D equivalent of pixels. Indeed, in this case, the projector screen itself consists of pixels.

As for LCD 3D printing, it does not have the reputation of the two others. There is not a big difference between LCD and DLP. This technique also flashes complete layers at the resin tank. However, in this case, the UV light comes from an array of LEDs and no device is required to direct the light as it is with the previous ones.

Credit: Zortrax



WHAT TO CONSIDER WHEN CHOOSING A RESIN 3D PRINTING TECHNOLOGY ?

Among all the additive manufacturing technologies that exist, resin 3D printing is mostly compared to FDM 3D printing. If the first reason that might explain such a comparison is the price of both types of technologies, it should be noted that other characteristics might help tip the balance in favour of one rather than the other. Indeed, the **printing process, design considerations, pre-processing, and post-processing** are very different.

More importantly, when it comes to compare resin 3D printing technologies to one another and how they **achieve the desired accuracy and precision**, these features – alongside materials and software settings - also come into play.

Indeed, we shouldn't forget that 3D printing remains an additive process. Therefore, each layer might lead to an opportunity for inaccuracy and the printing process can determine the level of precision of each layer.

Accuracy and precision are crucial in some applications like dental or surgical guides and despite the various analyses we could make, **reality shows that accuracy and precision are often better portrayed and evaluated when we discover the differences between machines supplied by various manufacturers**.

The most noticeable difference is size

The first and most noticeable difference between resin 3D printers and other types of 3D printers is size. If DLP 3D Printers tend to be much larger than their SLA counterparts because they house the actual projector, it should be noted that build platforms for resin generally seem surprisingly small – compared to other types of 3D printers. It is even possible to find a DLP 3D printer with the size of a cell phone screen.

Almost no tolerance for overhangs and bridging

It looks like there is virtually no tolerance for overhangs. If an unsupported overhang occurs during the printing process, it is likely to break or to remain stuck to the build surface, contaminating therefore the resin while interfering with the print. That being said, if a part orientation enables layer changes, this will reduce the steepness of overhangs, and therefore the need for supports.

A great investment in post-processing

As you may know, post-processing is no longer a step to neglect since every operator almost always has to go through it before getting the final and desired result.

Surprisingly, resin 3D printing requires more extensive post-processing in the form of part washing, additional curing, and support removal. The user must rinse the prints free of uncured resin. To do so, he just needs to wash them in isopropyl alcohol and dries them. After this stage, they may still require exposure to UV for additional curing.

However, in this specific case, the post-processing stage should not always be seen as the "dirty work" to do. With resin 3D Printing, depending on the resin material that has been chosen – as well as the post-processing and finishing possibilities, the operator can achieve a very nice rendering.

Why should we use one specific resin 3D printing technology over another?

To answer this question, we invited Fernando Hernandez, Head of EMEA at XYZprinting. For those who do not know the company, XYZprinting is a manufacturer of 3D printers based on different technologies including SLS, SLA, FDM, inkjet and DLP. One of their latest solutions is the PartPro120 xP, a DLP 3D printer.

Hernandez specifically explained the pros and cons of each resin 3D printing technology :

"It comes down to the taste of the chef in the kitchen. Each technology will have its fair share of pros and cons, but we maintain today that DLP technology now offers the best combination and balance of resolution, speed, build dimension and cost. That doesn't mean SLA doesn't continue to play a big role in the products we manufacture though, since it continues to provide very fine details for large building volumes, all the while keeping prices low.

LCD on the other hand is a technology that often falls short, for the reasons below:

1. LCD life is much shorter for UV light source. The life of the LCD panel with the UV LED back light wavelength (of 365 ~ 405nm) is generally very short (~ 1000 hours of life), which significantly increases the printing cost.

2. LCD uniformity is worse because of crosstalk issues. Once light is emitted from the pixels, it mixes with the light emitted from other nearby pixels. This effect favours consumer markets, since it smooths the image and prevents users from spotting any pixel mesh unless they are looking very closely. This works against 3D printing resolution though, as it means that the images are blurry and not crisp, meaning the models can't be well-detailed. In LCD, small details are lost, so things like small holes may be closed or not circular, for instance.

3. LCD's pixel size is larger than the DLP UV light source. Therefore, resolutions advertised on LCD panels are from the origin, but not the resolution at which the light source will reach the print bed.

4. LCD's light intensity is much weaker and this negatively affects the overall printing quality.

6. The source of an LCD panel is irregular. The LCD panel is used in the consumer market, meaning that printing special sizes is difficult and it doesn't guarantee supply and/or quality for 3D printing. For the moment, those panel prices are cheap because 3D printing is enjoying a wave of mass production of those panels for consumers Market (TV, tablets, etc). But once consumers jumps to other technologies, 3D printing market quantities won't be able to sustain the production and therefore it won't be possible to keep a similar market price to what is available now.

Meanwhile the print quality of the DLP printer exceeds LCD in multiple ways. The details are higher and within all resin technologies, DLP offer the lowest loss of details, and it also proportions from 3D model to physical. Historically, the biggest handicap for DLP was that it was difficult to get a decent building size for decent pricing, but that barrier is fixed nowadays; building plates are bigger and thanks to technologies such as our UFF (Ultra Fast Film) we are able to print up to 70 times faster than before, beating printing speed and productivity of equivalent technologies in FDM and SLA, while also beating in resolution and detail."

Fernando Hernandez

The good and the bad about resin 3D printing materials

In materials science, resin is a solid or highly viscous substance of plant or synthetic origin that can be transformed into polymers. Resins are usually mixtures of organic compounds.

As far as resin 3D printing materials are concerned, they enable the production of objects faster and with finer resolution than the other 3D Printing processes. This speed is due to the photo-curable resin that can produce small solid parts.

Apart from this noticeable advantage, it is vital to mention that resins can be toxic. Operators that handle such equipment might therefore be exposed to health issues. In the past, safety equipment was always part of the resin-based 3D printers' package that operators received. These precautions were also the reason why resin-based 3D printers were expensive and only used by industries.

Over time, with the proliferation of cheap although powerful resin-based 3D Printers, such machines are increasingly used in less-secured environments where safety protocols are often forgotten.

With the technology advancements, some material suppliers have been able to develop an eco-friendly resin.

Another disadvantage is the fact the durability of resin-printed parts is fragile. In fact, since the resin is first cured with UV light, the material can remain sensitive to UV exposure. In other terms, if the printed part is exposed to sun for too long, its resin could continue to "cure" until it breaks.

Credit: Zortrax

Applications of resin 3D printing technologies

The jewelry industry and the dental industry are the sectors that leverage the most resin 3D printing. The increasing use of resin 3D printing in the aforementioned sectors may have given this technology a reputation of technology designed for prototyping applications.

Fernando Hernandez disproves this "*popular belief*": "*Printed resin models are not only used for prototyping, but also for creating the finished product. The key to doing this well, however, is to identify the precise mechanical properties required for the part's final use. We need to consider the forces the end-product will be under, what temperatures it will be exposed to and more, and from there select the resin that is more suitable for the product's needs. Nowadays, the industry is seeing resin-based printers used for mass production of parts in the automotive industry, production machines and final parts, to name a few. At The New Kinpo Group, we use resin-based printers to print a variety of final product parts.*"

Furthermore, depending on the material used, it is possible to explore applications that go beyond these two sectors.

"*Certain resins can be more rigid, flexible and tougher than other resin strains. Some are able to simulate ABS mechanical properties while others have high temperature resistance, beating many of the most common thermoplastics. At times, the finished product of a resin-based model is smoother than its FDM counterpart for the same price range, making it a more viable and suitable option for creating final products*", explains XYZprinting spokesperson.

For instance, with a high-detail resin (usually compatible with PolyJet technology), the user can get a a smooth surface in the 3D printed part.

The mammoth resin for instance, has a great advantage: the printing of huge sizes. Such type of resins can be used in the production of bikes or a variety of works of art.

Another one is the Gray Resin. Ideal for the printing of figurines, the Gray Resin is a very smooth resin which is easy to paint.

Concluding thoughts

To sum up, resin-based 3D printers are getting more common and much more affordable. The user should keep in mind that affordability is not necessary synonym of bad quality. Also, they are not likely to replace filament-based 3D printers or metal AM 3D printers. The most important though, is to be aware of the pros and cons of each technology.

Lastly, a professional does not need to buy several 3D printers in order to know the one that best fits his interest. In addition to what we have said in the above lines, the inspection of real parts produced with these machines or a test print of a design might be enough to help him take his decision.

With an FDM 3D printer, you can create your own 3D resin printer

LumiBee is a unique mini 3D resin printer that uses smartphone as a light source to polymerize the resin. The project is free for everyone who wants to create their own device at home. To create it, all you need is a LPD printer. The LumiBee prototype was created on the Zortrax M200 3D printer.

The LumiBee is a unique compact 3D printer that uses photosensitive liquid resin. It has been designed so that 95 proc. of its parts can be printed with a desktop LPD 3D printer. The LumiBee also stands out because it uses the screen of a mobile phone, inserted inside, to transform daylight liquid resin into a three-dimensional object. Daylight resin for 3D printing allows most smartphones to be used as a light source to solidify the resin. This allows us to give a second life to slightly outdated cell phones.

"I made LumiBee as a personal project. I developed mechanical design, PCB design, prototyping, firmware and App. I made first prototypes for the chassis using the FFF 3D printer we have in house, a Zortrax M200 and Z-ULTRAT filament. M200 provided us with everything we needed. The quality was good enough even to print threaded bars and nuts for LumiBee Z-axis. An idea popped into my mind: LumiBee parts should be designed in a way that any user can 3D print them at home with a domestic FFF printer at a very low cost. I decided with my team to release LumiBee as free Open Source project by Lumi Industries, perfectly matching our mission to make 3D printing benefits available to a larger public", said **Davide Marin**, Lumi Industries CEO explains.

The LumiBee chassis design was split into "segments" with specific functions: holding the phone, housing the PCB board, etc., and they can be customized or replaced easily.

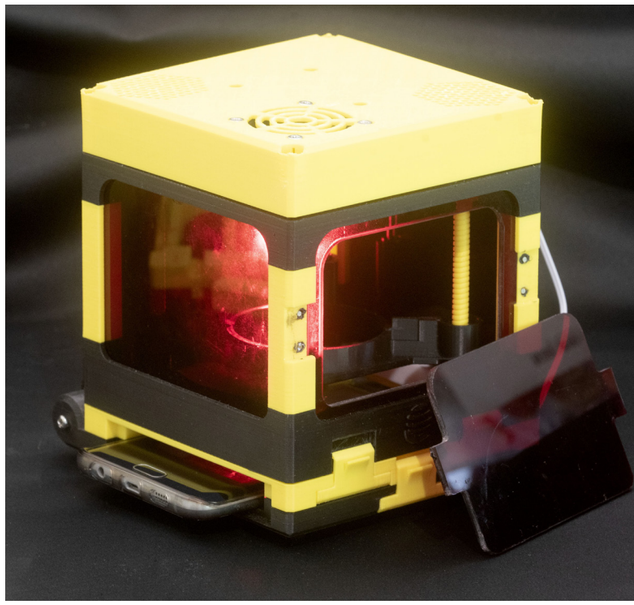
In prototyping process each segment was printed in a different color to highlight this feature. The name LumiBee is not an accident. At the prototyping stage, the studio had two filament colors available: black and yellow. The finished device resembled a bee, and this resemblance went way beyond appearance.

"In nature, this tiny animal has such an important role in our lives. It contributes to complex, interconnected ecosystems and we felt this reflected also the idea of the project itself involving different players like makers, 3D printing lovers and fans, as well as different companies to cooperate for the good and, if possible even improved, outcome of the project", adds Marin.

Partners of the project are Photocentric providing suitable daylight resins, Zortrax – creator of the printer on which LumiBee was printed and 3D Filium, suggesting particular filaments, like their new coming non-flammable PlaQ FRVO, perfect for extra safety when embedding electronic components. *"We are glad that users of Zortrax printers use our equipment for creative projects and share their solutions with the tech enthusiasts community. The ability to create your own devices, modify and improve them is one of the most important things 3D printing brings to the table. We are excited to see how people will transform and modify LumiBee in the future"*, said **Rafał Tomasiak**, CEO of Zortrax.

LumiBee open source project looks simple, but hides some smart solutions. For example, LumiBee communicates easily with any smartphone in the market. Every smartphone has a built-in flash for the rear camera, and accessing it is easy in Android studio. Communication protocol was reduced to the bare minimum, using a quick blink of the smartphone flash to say *"go up 1 layer in the Z-axis"* to LumiBee and 2 quick blinks to communicate *"print is finished, put the tray completely out of the resin"*.

Feel free to download the files from the site: ***www.lumindustries.com/lumibee*** and start creating your own machine.



HOW ADDITIVE MANUFACTURING IS CHANGING THE R&D INDUSTRY?

With contributions from the **Fraunhofer Additive Manufacturing Alliance, IPC & nScrypt**

Contrary to what people conventionally think, Research & Development (R&D) is a very manageable driver of corporate success. If you think for a second, the biggest innovations that are shaking the world of today started with R&D. This stage has been fundamental in any industrial revolution, including additive manufacturing (AM), and today, we want to discover how this technology is driving this sector.

The manufacturer's ability to innovate and adapt to its customers' requirements has never been important as it is today. To respond to these industry needs, many manufacturers find themselves investing in their research, design and test capabilities. Manufacturing therefore has to be flexible and with the advancements in additive manufacturing and other technologies, we observe a shift in the paradigm of the R&D industry.

Indeed, the advancements in additive manufacturing and its increasing use in R&D might raise confusion since it is now difficult to perceive if AM drives the R&D industry or if the R&D drives the AM technology advancements.

For **Kenneth Church**, CEO of nScrypt, the answer is both. *"AM is maturing but there is still so much more to learn, to improve and to transition. R&D is the beginning of all great technology but the difference here is that AM provides so many new beginnings. AM is and will make such a broad impact, it is hard to put it into one single category.*

Church reminds that AM is not a new technology. The technology has been introduced in the 1980s. Many have proposed reasons why AM has grown so rapidly a number of years ago, but the main one would be tied to patents expiring and enhanced 3D software. The more people can use a software, the more they leverage 3D printing. Speaking of their experience, Church said they were using AM in 1999 on electronics. They printed capacitors using multi-materials and a layer by layer approach.

Kenneth Church
CEO of nScrypt

"AM will also and has already, flipped the tables and will change the R&D community. Many look at AM as simple 3D objects or even complex 3D objects that you cannot fabricate any other way, but what most are missing is the intrinsic value that comes from the complex shapes or the melding of materials. Metamaterials [for instance], have been a big buzzword for many years but achieving certain metamaterial designs has been out of reach due to the complexity of the physical object. If you could fabricate the complex metamaterial object, you could discover new electrical, magnetic and even thermal properties that are not possible with material alone."

What's that shift in the paradigm of the R&D industry?

R&D may be a crucial means for achieving future growth and maintaining a product in the market but it is a misconception that it is the domain of high-tech technology firms or even pharmaceutical companies.

The truth is, where most other firms may only spend less than 5% of their revenue on research, industries such as pharmaceutical, software or high technology products like additive manufacturing systems, need to attribute a more significant percentage due to the nature of their products. The paradigm appears therefore in the way this R&D activity is led.

Reducing lead times

It does not look like it is but the more we advance; the less R&D projects take time. R&D projects are recognized for their long-term commitment/investment. However, it should be noted that the use of new technologies might reduce the research time in a given project, while opening the door to a more tailor-made solution.

Additive Manufacturing for instance, is known as a technology that enables to reduce lead times.

Companies within the medical device sector for example, invest more and more in 3D printing technology, with industry leaders like Stryker announcing plans to invest €200 million in research, development and innovation at its Cork site. Such an investment in R&D would enable the medical company to produce customized 3D printed implants which can be used where a patient requires a more specific reconstruction, and where off-the-shelf product wouldn't be suitable.

Image credit: Renishaw – Spinal implant

However, despite the benefits announced by this innovation (benefits of bone growth with 3D printed implants), the limitations remain a big hurdle in the adoption of new spinal implants, as the extensive cost of the equipment does not enable yet a majority of people to afford the products made with it.

Proliferation of R&D activities in private sectors

Another interesting observation is that, unlike in the past where R&D was mostly part of the public sphere, private sectors increasingly leverage R&D expertise. However, in this specific case, the R&D activity of industrial projects has recently been restructured with the goal of providing short-term benefits.

According to Dr. Bernhard Mueller, *"AM is well-researched in manifold ways and R&D activities have globally exploded. The biggest challenge is to bridge the gap to industrial application, generating more business cases. Only few business cases have so far been proven and industrialized (hip cup implants 3D metal printed via EBM technology, repair of gas turbine burner tips via L-PBF metal AM technology, dental caps via L-PBF metal AM technology, aerospace ducts and hoses via polymer AM)."*

For instance, most of the launches that have recently been made in the additive manufacturing industry are the result of in-house R&D activities of companies.

Dr. Bernhard Mueller affirms for instance, that they use all relevant AM technologies (laser or other beam-based technology, powder bed as well as material deposition, binder jetting, bioprinting etc.) and process all types of materials (metals, polymers, ceramics, biomaterials). *"Major applications have been successfully investigated at Fraunhofer including prove of industrial applicability, e.g. AM tooling for hot metal processing technologies, functionally integrated medical implants, several flying parts in aerospace developed at Fraunhofer jointly with industrial aerospace partners"* **Mueller** continues.

Dr. Bernhard Mueller
Spokesperson of the Fraunhofer Additive Manufacturing Alliance

To mention other examples, the recent 3D printers that have been launched on the market are the result of extensive R&D activities: HP 5210, XJET Carmel 1400, the 3DGence Industry F420, the da Vinci Color 5D 3D Printer, to name a few of them.

In industries such as the automotive, one can mention the increasing use of additive manufacturing for prototyping parts. Two years ago, car manufacturer Volkswagen sets the goal to fabricate a 3D printed car. To do so, it opened a 3D printing centre in its Toolmaking unit in Wolfsburg. While leveraging several metal AM technologies, the automotive specialist plans to produce complex vehicle components both for prototyping and series production.

"The 3D printing centre takes VW's additive manufacturing activities to a new level," Dr. **Andreas Tostmann**, Volkswagen brand production chief, commented during the opening ceremony. *"In two to three years' time, [3D] printing will also become interesting for the first production parts. In the future, we may be able to use 3D printers directly on the production line for vehicle production."*

The opening of this center brings the company's activities in AM to a new level. Indeed, the car manufacturer already customizes components such as key rings and exterior-mounted name plates. Using HP's binder jetting, it will be able to produce quality functional parts with significant structural requirements.

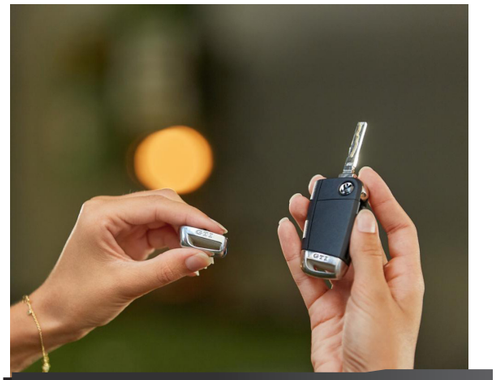
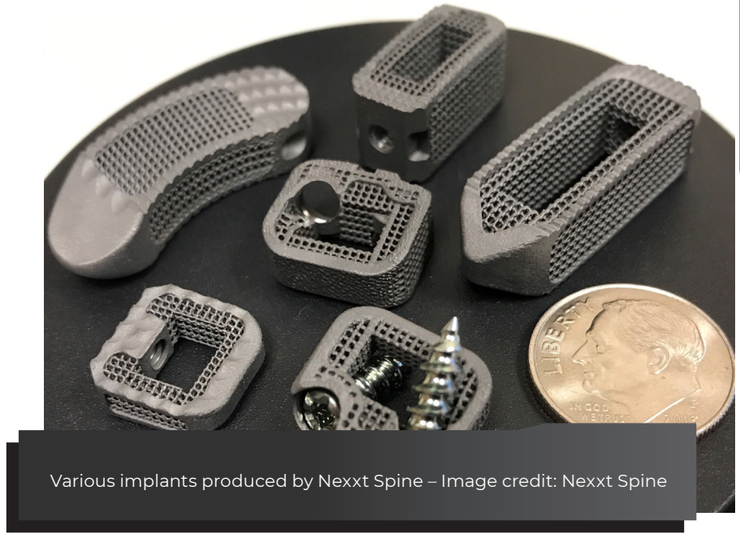


Image credit: HP

Collaborations, the must?

No matter what anybody says, R&D activities require investments that companies cannot always afford, which is why collaborations often remain a viable alternative. Several types of collaborations therefore exist, collaborations between R&D centres and AM companies, collaborations between companies and universities, or even collaborations between R&D centres.

One interesting form of collaborations that has recently been implemented in order to help SMEs to accelerate the product development of their products onto a given market while leveraging AM is AMable. It is actually a European project whose aim is to foster the development of AM by SMEs. Funded by the European Union's horizon 2020 Research and Innovation Program, the project aims to support companies in the adoption of AM technologies.



Various implants produced by Nexxt Spine – Image credit: Nexxt Spine

In order to better serve SMEs, the network brings together the main technology centres located across the EU, and supports them in the development of their ideas: from the concept stage, the construct and print stages to post-production phases.

The increasing use of AM as a R&D tool

Beyond this shift of paradigm in the R&D industry, it is interesting to appreciate how exactly AM is used as a tool in R&D. Indeed, while the novelty of a solution may lead to the dismissal of the oldest one, it should be noted that in the R&D sector, the technology remains a tool among other tools.

Nathalie MAILLOL, Additive manufacturing project leader at IPC, comments: *"AM is a complementary tool [alongside] other production processes, not a substitute. I think AM changes the R&D industry as people begin to think [of it] as [a] process with a lot of potential, not only a [prototyping tool]."*

Indeed, when we look at R&D centres be it private or public, AM is rarely the only technology that is leveraged.

nScrypt for instance, does have traditional machining and electrical prototyping. According to Kenneth Church, these provide fundamental value in research, but to progress to new concepts, [they] have moved to the nScrypt 3Dn Direct Digital Manufacturing tool which has printing, machining, printed electronics and pick and place in a single tool. nScrypt has coined this the Factory in a Tool (FiT). *"From this we can fabricate monolithic circuits such as an Active Phase Array Antenna where the active electronics are part of the antenna element"*, said the CEO.

Nathalie MAILLOL,
Additive manufacturing project leader at IPC

Maillol explained that, from its early beginning, the centre mainly focused on plastic injection. *"In 2001, IPC began to work on laser powder bed fusion in order to build mould insert with cooling channels. These channels have a complex geometry that can [only be produced using an] AM process."* This experience has led the AM team to explore the possibilities offered by other types of AM technologies in R&D projects. Today, in addition to metal AM technology, their portfolio includes SLA and different types of FDM 3D Printers (among which large format printers, PEEK or composites-based 3D printers).

Those 3D printers might be a great tool but sometimes, their capabilities need to be enhanced in order to obtain expected results, to reduce costs or simply save time.

"We work with different machine providers to develop exposure parameters or to study powder recyclability. Recently, thanks to a European project, we could have equipped one of our machines, EOS M290, with monitoring systems: OT (Optical Tomography) and MPM (MeltPool Monitoring). They are in-line systems, which means that they watch the production running and collect data to evaluate the quality of the process. The objective is to detect if the melting of a part presents a deviation (like porosity or lack of fusion) during the production. [Such type of] equipment gives a clear advantage as a quality tool and avoid post-production test such as X-ray tomography which is expensive and time consuming", explained the AM project leader.

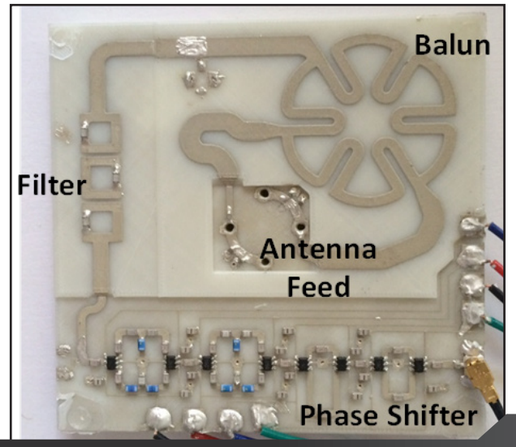


Image credit: nScrypt – Legend: Active Phase Array Antenna - The figure above is 7 RF functional layers, but it also was intentionally made thicker, which meant more layers, to accommodate the distance from antenna to the ground plane and this also provided a structural aspect. This means the structure is both strong and electrically functional, welcome to the future.

The use of AM as a R&D tool might therefore enable researchers to evaluate both the advantages and disadvantages of the technology, and in some cases leads to improvements.

For IPC's spokesperson, depending on the goal of the research, AM fosters many other developments. These developments can for instance, be observed at the material or the parameters level. *"The development of monitoring systems is on the way in order to reach the right first-time manufacturing. The common point is to reduce the cost for parts produced with AM process. So, I expect more projects to investigate if AM is suitable for serial production and I also expect more development to improve the success ratio of AM productions,"* concludes **Maillol.**

The specific use of AM in medical research

When it comes to research, 3D printing is widely used in medical-dedicated researches and several purposes explain the use of the technology: the generation of accurate replicas of a body part, reconstruction and plastic surgeries, customized implants as mentioned earlier.

"R&D in AM will continue to increase, providing more and more technological breakthrough developments in terms of cost, multi-material AM, reliable ultra-light-weight structures, process reliability, application-specific technology portfolio widening etc." said the spokesperson from the Fraunhofer Additive Manufacturing Alliance.

Credit: Avinent – 3D Printed anatomical model produced with Stratasys technology

Interestingly, the advancements of the technology have led to the development of a new one: **3D bioprinting**. Built on recent advances in 3D printing techniques, this manufacturing process aims to engineer different types of products involving biological components, including human tissue and, more recently, vaccines.

While the concept of bioprinting is not entirely a new one, the increasing advancements in the field raise legal and regulatory questions regarding their effective use on humans.

In a nutshell

Our paper demonstrates that Additive Manufacturing also has a disruptive effect in the R&D industry:

At a structural level, the technology allows the creation of dedicated R&D centres committed to exploring the advancements of the technology, the proliferation of R&D centres in private sectors and a wider collaboration between companies, universities and R&D institutes.

At the internal level, the technology remains a R&D tool used alongside other manufacturing processes, which is a good thing as, the more researchers will depict the areas for improvement of the technology, the more manufacturers might be able to develop high performance machines.

We couldn't agree more with Kenneth Church when he says: *"the task in front of us is daunting, but it is not insurmountable and it is important. We need to continue to push the R&D in AM and this will drive R&D to a whole new place. R&D will be faster due to accessibility to fabricated prototypes with unique properties. AM will also disperse the R&D. Today, labs that have very expensive equipment get to have most of the fun. Tomorrow, your garage will be a lab and you will get to join the fun. Software will improve and what once was only for highly trained CAD users is now in your physical hand, your phone, you will create what highly trained CAD people might not have thought of."*

Last but not least, among all R&D sectors, vital sectors such as the medical industry remain a crucial focal point. Indeed, 3D Printing led to the development of new manufacturing techniques, techniques that might drastically change people's lives but regulations are not yet ready to cope with this change. Nevertheless, it's the job of R&D to convert requirements -- from consumers, government and others -- into specifications.

About the contributors

Two research centres and a manufacturer joined us to discuss this dossier:

- The Fraunhofer Additive Manufacturing Alliance which integrates 20 Fraunhofer institutes across Germany and represents the entire process chain of additive manufacturing. This includes the development, application and implementation of additive manufacturing methods and processes.

The Institute brings several years of experience from national and international industrial contracts and research projects form the basis to develop customer-specific concepts and master complex tasks. Their activities focus on five major research areas: engineering (application development), materials (polymers, metal, ceramics, biomaterials), technology (powder-bed-based, extrusion-based, print-based), quality (reproducibility, reliability, quality management) as well as software and simulation (process control algorithms, process and product simulation).

The aim of the alliance is to advance applied research and development and to start trends in additive manufacturing. The Fraunhofer Additive Manufacturing Alliance works with industry sectors such as automotive and aviation, but also biotechnology, medical and microsystems technology as well as tool manufacturing, mechanical and plant engineering.

- With an acronym that comes from "Innovation – Plasturgie- Composites", IPC is the National and Industrial Technical Centre for Plastics and Composites. The industrial centre works with France-based companies from different sizes and brings them its expertise in plastics and composites.

- nScrypt is a US-based company that designs and manufactures high-precision microdispensing and Direct Digital Manufacturing equipment and solutions for industrial applications. The company has recently developed and launched its first Ruggedized Precision 3D Printer/Bioprinter. The company has been pioneers in 3D printed electronics. Their drive is to move the industry from Printed Circuit Boards (PCBs) to Printed Circuit Structures (PCS). This means the structure will be a specific shape, any shape and the electronics will be permeated throughout the structure; it is next generation electronic packaging. This will save weight; improve performance and reduce costs.

INTERVIEW

Fuselab 3D aims to bring a different FDM technology onto the 3D printing market

An additive manufacturing veteran once told 3D ADEPT Media that, "*from a technology perspective, there is a clear additive manufacturing footprint in Belgium. (…) [However], Belgian companies should realize that it is time to invest in technology.*" A few companies including Materialise, Twikit, aerosint, etc. have understood this statement at a very early stage and have proven their willingness and ability to push forward the boundaries of technology. Today, they are sources of pride for the kingdom of Belgium and another company that will very soon join this club is Fuselab 3D.

Founded by **Jonathan Palmaers**, the company is still at the early beginnings of its journey, yet is committed to providing added value where we did not expect. We discovered Fuselab 3D at the latest Formnext event, where the company was making its debut with a unique technology, an industrial FDM 3D Printer named Fuselab FL300.

FDM is certainly the most known and most commonly used additive manufacturing technology. Because it is seen as the simplest one to use, professionals tend to believe that no improvement can be made. As an electro-mechanical engineer and a true nerd, Jonathan Palmaers thinks otherwise.

Palmaers has really hit upon the additive manufacturing market, while he was working in an automotive company. They used a FDM 3D Printer to ensure the prototyping and testing activities. Assigned to the R&D department, he discovered what AM could do to speed up the development process of a new product.

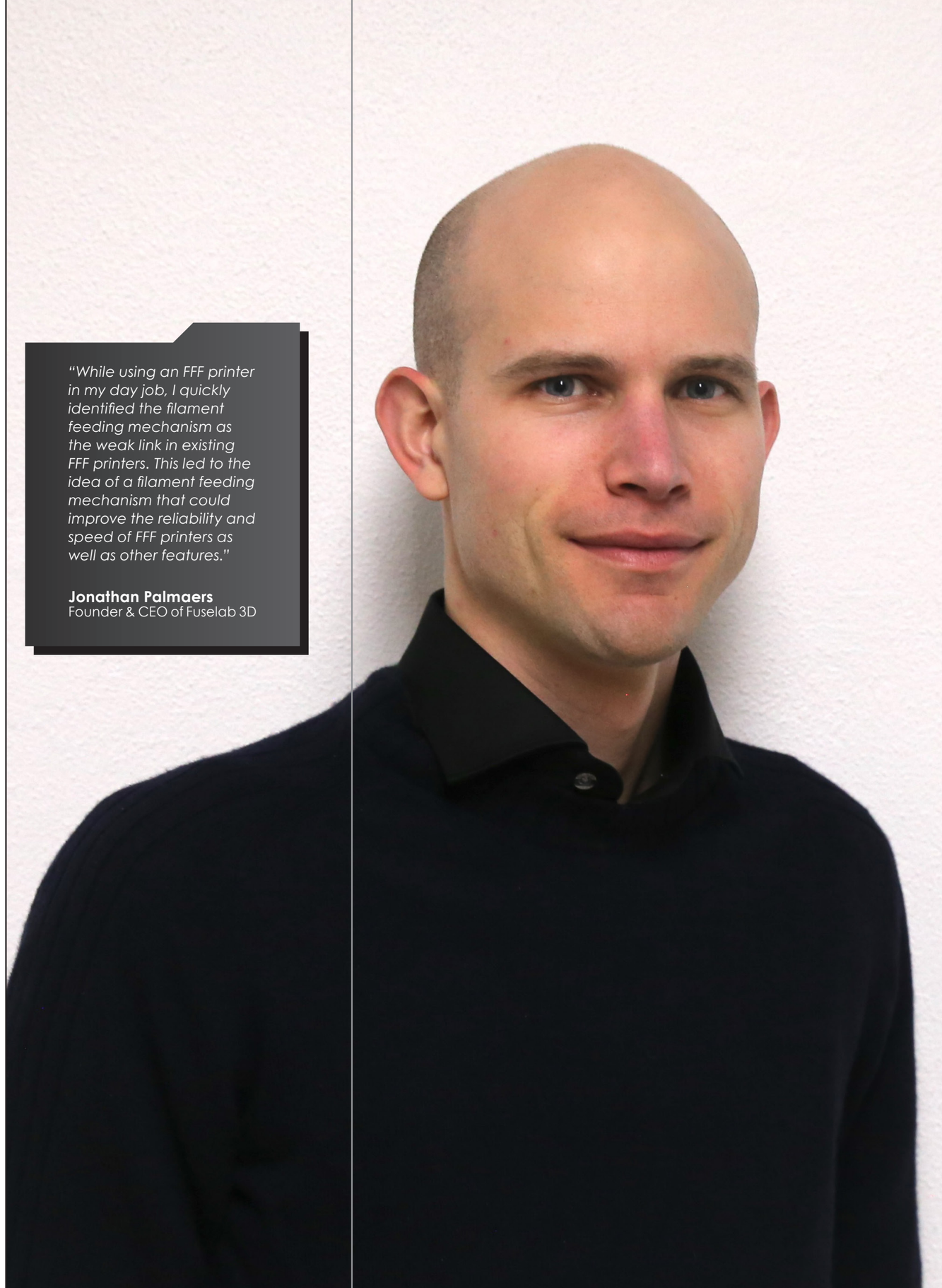
"I found it fascinating how complex prototypes could be additively manufactured without the long lead times we were experiencing with traditional methods"

"*I found it fascinating how complex prototypes could be additively manufactured without the long lead times we were experiencing with traditional methods*", said **Palmaers**.

However, leveraging FDM 3D Printing in this automotive company has also enabled the electro-mechanical engineer to identify some areas for improvement on the technology. In this Opinion of the Week, Palmaers tells us what is this area for improvement, how exactly the 3D printer is outstanding and what's next for the company.

"While using an FFF printer in my day job, I quickly identified the filament feeding mechanism as the weak link in existing FFF printers. This led to the idea of a filament feeding mechanism that could improve the reliability and speed of FFF printers as well as other features."

Jonathan Palmaers
Founder & CEO of Fuselab 3D



What led to the development of the Fuselab FL300?

While using a FFF printer in my day job, I quickly identified the filament feeding mechanism as the weak link in existing FFF printers. This led to the idea of a filament feeding mechanism that could improve the reliability and speed of FFF printers as well as other features. After 2 years of building prototypes and testing the new extrusion mechanism, Joey Symons, my business partner and I founded Fuselab 3D, dedicated to the development and commercialization of an FFF 3D printer.

Fuselab FL300

How does the Fuselab FL 300 stand out from the crowd?

The new and proprietary extruder that we developed allows faster printing while delivering higher quality parts. It also enables much better reliability while printing, since the risk of filament grinding is practically reduced to zero. The FL300 also features a structural frame that is independent from the exterior casing for better geometric accuracy of the printed parts. Finally, the heated build platform features a new mounting system that allows it to expand freely and symmetrically when heated, this results in better looking parts without shifted layers due to thermal expansion.

The fully enclosed build volume allows us to filter the air coming out with a HEPA and active carbon filter, this makes the printer safe to use in small spaces. The filament is stored in a hermetically closed drawer to prevent filament degradation due to absorption of humidity.

So far, the biggest challenge for the start-up was to make the "new extruder concept" work and the company seems to have successfully met this challenge.

As far as materials are concerned, the founder said that, apart from flexible materials, the 3D printer can process almost all materials.

The company has made its first entrance into the international scene at Formnext; what was the company's objective for the show?

The first objective was to get some feedback with respect to our new extruder innovation and the specifications of the printer in general. We also wanted to validate if our internal priorities/goals aligned with the priorities of potential customers. It turned out that our idea of what customers expected aligned quite nicely with what we were offering, so our marked research was validated.

Secondly, we wanted to make some business contacts with potential resellers for when we are ready to start selling our printer.

When can we expect the commercialization of the 3D printer?

The printer we showed at Formnext was still a prototype, but very close to the final design. We are finalizing the design in the coming months, and preparing to start production in the summer of 2020.

In a nutshell…

The Fuselab FL300 brings a new additive manufacturing approach to those who leverage FDM technology. Intended for both professional users and R&D centers, the technology can also be used for series production applications.

Fuselab 3D still has a long way to go but the company is already on the right track to succeed in its mission: "*to bring some innovation to the FFF printer market, innovation that [they] feel, has been absent in the last few years*".

NEWS ROUNDUP :

First trends of 2020 turn around “sustainability”

The first weeks of 2020 are marked by interesting developments in the R&D industry. From materials to 3D printed medical solutions, the use of additive manufacturing gives hope for a better world or simply better products.

One main trend: sustainability

Sustainability is set to be one of the key topics that will be addressed in 2020. Companies are discussing about this issue and are looking for new solutions that will enable a more “green manufacturing”.

The topic has been announced as the main topic of Materialise World Summit. Other companies like Sintavia have taken steps in that sense by launching the Additive Manufacturer Green Trade Association, or AMGTA.

The AMGTA is a non-commercial, unaffiliated organization that is open to any manufacturer that meets the following basic criteria:

1. Has generated the majority of its manufacturing revenue through AM over the most recent fiscal year.

2. Has adopted proactive internal policies relating to waste reduction and operational sustainability.

3. Is a member of the Green Business Bureau or another similar certifying agency.

4. Is willing to actively participate in the advancement and non-commercial promotion of the environmental benefits of AM within end markets and with the general public as a whole.

Research & Development

New Research gives hope to fight against infertility: “3D printing ovaries”

A group of researchers has recently achieved a significant milestone in the 3D printing o an artificial ovary for human implantation. The researchers have identified the location of structural proteins within a swine ovary, a finding that will contribute to the ongoing development of an ink. That ink will contain proteins and will be used in the fabrication process via AM.

“This is a huge step forward for girls who undergo fertility-damaging cancer treatments,” explained Monica Laronda, PhD, senior author of the work and Director of Basic and Translational Research, Fertility & Hormone Preservation & Restoration Program at Ann & Robert H. Lurie Children’s Hospital of Chicago. “Our goal is to use the ovarian structural proteins to engineer a biological scaffold

capable of supporting a bank of potential eggs and hormone producing cells. Once implanted, the artificial ovary would respond to natural cues for ovulation, enabling pregnancy."

The research underwent its first milestone in November 2019 when Laronda received a patent for the fabrication of an artificial ovary. Together with the team, they 3D printed a synthetic ovary and implanted it into a mouse in one trial. After a successful pregnancy, the mouse gave birth to offspring. From then on, Laronda and her colleagues remain optimistic about translating this discovery into a solution for women.

“The structural proteins from a pig ovary are the same type of proteins found in humans, giving us an abundant source for a more complex bio-ink for 3-D printing an ovary for human use,” Laronda said. “We are one step closer to restoring fertility and hormone production in young women who survive childhood cancer but enter early menopause as a late effect. There are still several steps to go and we are excited to test our new inks.”

With the success of this milestone, the team ambitions to achieve the effective 3D printing of artificial organs.

“We have developed a pipeline for identifying and mapping scaffold proteins at the organ level,” Laronda concluded. “It is the first time that this has been accomplished and we hope it will spur further research into the microenvironment of other organs.”

Applications

Speaking of applications, Native Shoes is certainly the brand that you should keep in your mind. The brand surfed on the wave of sustainability by 3D Printing two of its most popular footwear designs.

Made out of plants and recycled materials, The Canadian footwear company collaborated with MIT’s Self-Assembly Lab to fabricate the shoes. Together, they experimented an unusual design named Liquid Printed Natives.

After designing the shoes on a computer, the team 3D printed them into a container of reusable, water-based gel formula. They are printed in liquid rubber using a patented 3D Printing technique.

In this specific case, the team explained that the shoes can be made from 50% recycled EVA – a percentage that is not possible to reach with injection moulding techniques-. This process might be longer but the company believes the “speed-to-market” is definitely faster than for its injection-moulded shoes.

For now, Native Shoes 3D printed footwear would still be in the internal testing phase, so no release date has yet been announced.

Scientists successfully 3D bioprint with Human Heart Cells in space

Techshot Inc. has successfully printed with a large volume of human heart cells aboard the International Space Station (ISS) U.S. National Laboratory.

The 3D bioprinter has been developed in collaboration with nScrypt, a manufacturer of industrial 3D bioprinters and electronics printers.

“Our BFF [for 3D BioFabrication Facility] has the potential to transform human healthcare in ways not previously possible,” said Techshot President and CEO John Vellinger. "we're laying the foundation for an entire industry in space.”

Techshot Incs. aims to make the device available

for commercialization at the end of the next round of test prints in March. Furthermore, the company believes that both its industrial and institutional life science customers could make the most of this technology. With five commercial research and manufacturing payloads aboard the station, Techshot Incs. has the largest catalog of any American company operating inside the orbiting lab.

The manufacturer is currently developing a sixth payload, the Techshot Cell Factory, that will enable users to continuously generate multiple cell types in space for biomanufacturing, 3D printing and other uses. Having a reliable source on orbit is expected to limit Techshot's reliance on cargo resupply spacecraft bringing cells up from Earth.

While the 3D printer's bio-ink contained cell types such as heart muscle cells, nerve cells and vascular cells, it notably did not contain the scaffolding materials or thickening agents normally required to resist the destructive pull of gravity when bioprinting on Earth.

"Though researchers have had some success with 3D printing bones and cartilage, the manufacturing of soft human tissue (such as blood vessels and muscle) has been difficult. On Earth, when attempting to print with soft, easily flowing biomaterials, tissues collapse under their own weight – resulting in little more than a puddle. But when these same materials are used in the microgravity environment of space, the 3D-printed structures maintain their shapes."

Last month's test prints in space were large by Earth bioprinting standards. Each measured 30 mm long by 20 mm wide by 12.6 mm high. The BFF printed inside a Techshot-developed cell culturing cassette that strengthens the assemblage of cells over time; to the point where they should become a viable, self-supporting tissue-like structure expected to remain solid once back in Earth's gravity.

Three Techshot culturing cassettes, each containing one tissue-like construct, will be returned to the company following this week's Pacific Ocean splashdown of the SpaceX Cargo Dragon capsule at the end of mission CRS-19. More 3D bioprinting in space will take place in March of this year following the launch of additional bio-inks to the ISS National Laboratory aboard SpaceX mission CRS-20.

Though the prospect of manufacturing human hearts and other organs via a 3D bioprinter in space is likely a decade away, it is hoped that the long-term success of BFF could lead to a reduction in the shortage of donor organs.

Materials

In the materials sector **CRP Technology** and **Fossilabs** launch new 3D printing materials.

CRP Technology completes the P-LINE family with the Windform® P2, a glass fiber reinforced thermoplastic polyamide material. The polymer distinguishes itself from its predecessor by its increased mechanical properties: increased stiffness (Windform® P2 Tensile Modulus is 2925.20 MPa whereas Windform® P1 is 1960.60 MPa), combined to high tensile strength (39.24 MPa, Windform® P2).

Fossilabs on the other hand, launched a FFF 3D printed 'fully' porous PEEK bone-like structures within implantable devices. The US-based company specializes in engineering porous bone-like structures in polyether ether ketone (PEEK).

"Using 3D printing technology makes it possible to create a porous structure that would not be possible using traditional methods. The increased surface area and the full porosity encourage new bone on-growth and in-growth of the implant, leading to greater integration strength. Add hydroxyapatite (HA) nanocoating, now you have something unmatched in the industry," said Todd Reith, Founder/ President at FossiLabs.

Now that the solution has proved its worth, the company aims to partner with medical device companies to license its technology.

3D Printers

In the 3D Printers area, XYZprinting unveils upgraded da Vinci Color 5D 3D printer. Don't be confused by the provocative name. The new 3D printer integrates both an inkjet and FFF/FDM technology. With laser engraving capabilities, it is designed to combine "the 2D and 3D printing experience" of users.

ADDITIVE MANUFACTURING EVENTS IN 2020

Pick up the latest issue of your trade magazine in all the major events dedicated to additive manufacturing

TCT Japan - January 29-31st - JAPAN
3D Medical Printing Conference & EXPO - February 04-05th - The Netherlands
Prototyping 2020 + Machineering Network event. - February 05-06th - BELGIUM
Additive Manufacturing for Aerospace & Space (TBC*) - February 25-27th - UK
Japan largest 2nd Additive Manufacturing Expo- February 26-28th - JAPAN

JEC World (TBC*) - March 03-05th - FRANCE
RapidPro - March 04-05th - The Netherlands
APS Meeting - March 10-11th - FRANCE
Metav 2020 - March 10-13th - GERMANY
4th Additive Manufacturing Forum
March 11-12th. - GERMANY
Global Industries
March 31st – 03rd Apr - FRANCE
Manufacturing World Nagoya
April 15th -17th - JAPAN
3D Printing Value Chain Event
April 21-22 - The Netherlands
Hannover Messe
April 20-24th - GERMANY
3D Printing Europe
May 13-14th - GERMANY

3D Printing 2020
May 18-19th - FRANCE
The Advanced Materials Show and Ceramics
July 08-09th - UK
3D Print Lyon
June 16-18th - FRANCE
TCT Show 2020
September 29 – October 1st ,Birmingham, UK
Metal Madrid
September 30th – October 1st - SPAIN
Euro PM2020 Congress & Exhibition -
October 4- 7, Lisbon, Portugal
Formnext
November 10-13th - GERMANY

3D ADEPT MEDIA

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