Benesch

3D Printing Quarterly Report—Q2 2019

3D PRINTING–A FAST-MOVING MARKET

# Developments in 3D Printing

## A Sector by Sector Overview

This report explores developments in 3D printing across several sectors and categories for the quarterly period of April 1, 2019 to July 15, 2019.


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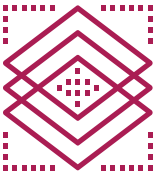
## General

**Daimler NextGenAM project develops inexpensive 3D printing process for metal hardware**

Daimler's NextGenAM project to develop an automated metallic 3D printing process has concluded. Launched in May 2017, the results of the pilot demonstrate the potential to replace conventional aluminum part manufacturing techniques and cut costs by up to 50% in comparison to traditional 3D. The project is conducted in partnership with Premium AEROTEC and EOS. Daimler claims no manual work is required at any stage of the process. The additive manufacturing process is currently being used by Daimler's truck unit creating replacement brackets for truck diesel engines.



## Materials

**ColorFabb launches "foaming" LW-PLA 3D printing filament**

3D printed filament specialist ColorFabb released the LW-PLA, a first-of-its-kind, lightweight filament using a novel active foaming technology to achieve low-density, light PLA 3D printed parts. The new filament will begin to "foam" at around 230°C, increasing its volume by nearly three times. This allows users to decrease material flow by roughly 65%, resulting in more-lightweight parts. The foaming technology also makes it possible for users to reduce print times by using bigger layer heights or single extra-thick perimeters. The new 3D printing filament is available in two colors: black and neutral.

**Sandvik unveils 3D printed diamond**

Sweden-based Sandvik has produced the first synthetic diamond composite printer, which could be suitable for a wide array of industrial or medical uses. However, the material is not suitable for accessories or jewelry. As opposed to natural or other synthetic diamonds, Sandvik's diamond is a composite material. Most of the material is diamond, but to make it printable and dense, it needs to be cemented in an extremely hard matrix material. Due to Sandvik's use of additive manufacturing, diamond components can be created application-ready, in very complex shapes and without the need for further machining.

**Swedish researchers 3D print wood**

Researchers from Sweden`s Chalmers University have demonstrated a 3D printing process that uses a wood-based ink to produce components with the unique "ultrastructure" of wood. This enables the technique to reproduce many of the desirable properties of natural wood, including porosity, toughness and torsional strength. The breakthrough builds on earlier research carried out by the team in which a 3D printing ink was produced by converting wood pulp into a nanocellulose gel. In the future, the technology could enable wood products to be "grown" to order, allowing the metals and plastics currently used in 3D printing to be replaced with a renewable, sustainable alternative. Alongside applications in healthcare products and clothing, the process could allow for the technology in space.

**Korean researchers 3D printing with liquid metal**

Researchers from Yonsei University have explored a new technique outside the usual realm of metal 3D printing: liquid metal 3D printing. The researchers examined creating "stretchable" 3D integrations formed into "diverse 3D structures," creating a reconfigurable antenna utilizing the technique. Furthermore, they believe the high-resolution 3D reconfiguration method offers a promising strategy as an additive process that can be combined with conventional fabrication techniques for highly integrated and stretchable devices, indicating substantial promise for use in next-generation electronics.

## Printing Techniques & Capabilities

**New multimaterial SLA 3D printing method skips liquid bath with aerosol jet printing**

German researchers created a hybrid form of SLA 3D printing to streamline and expand production. The team developed a spray-coating device, which is "able to process inks in the range between 10 and 1000 mPas. UV curable materials with greater viscosity compared to inkjet-based raw materials can be used to establish a material layer and open the field for a wide range of materials. The modified system allows the mixing of two different materials through the addition of a second spray generator." Compared with a conventional inkjet system, the AJS is superior in processing liquids, relying on two atomizers.

**Scientists 3D print all-liquid lab-on-chip**

Researchers at DOE's Lawrence Berkeley National Laboratory have 3D printed an all-liquid device that can be repeatedly reconfigured on demand to serve a wide range of applications from making battery materials to screening drug candidates. The 3D printed device can be programmed to carry out multistep, complex chemical reactions on demand. The device builds upon a study in 2018 coauthored by a visiting researcher from the University of Massachusetts, which pioneered a new technique for printing various liquid structures, from droplets to swirling threads of liquid, within another liquid. The technology is available for licensing and collaboration.

**3D printing supercapacitors with graphene oxide ink**

Chinese researchers delved into the fabrication of 3D printed energy storage devices, using graphene-based inks for making supercapacitors. The team focused on the benefits of direct ink writing, suitable for creating structural and electrical materials, along with biological materials. It is normally extruded through a needle, or through mechanical pressure. Graphene oxide also offers better dispersing capabilities, but it must be delivered in the proper concentrations to offer a "liquid to soft solid transition." The findings hold great promise and are very informative for the realization of futuristic high-energy-density supercapacitors in limited footprints for miniature electronics.

**MIT's Inkbit creates industrial 3D printer with "eyes and a brain"**

Inkbit, a startup of the Massachusetts Institute of Technology Computer Science and Artificial Intelligence Laboratory, developed an industrial 3D printer with machine-vision and machine-learning technologies. The machine is the first with the capability to learn the properties of a material and predict its behavior. The development may enable researchers to create a usable product quicker from an idea, opening business opportunities.

**French researchers develop algorithm to generate interior ribbed support vaults for 3D printed hollow objects**

French researchers from the Université de Limoges and the Université de Lorraine proposed a new method for hollowed 3D printed objects. While most people think of 3D printing supports as external ones that support overhanging parts of an object, the interior of an object may also need ribbed support vault structures. The idea is to use three main operations to produce supports: propagating and reducing supports from the above slice, detecting areas that appear to be unsupported in the current slice, and adding the supports needed for it. The researchers believe that their method for 3D printing hollowed objects through generating ribbed internal support structures could one day lead to novel external support structures as well.

## M&A and Investments

**Cummins expands portfolio by investing in GE Additive's metal binder jet 3D printing technology**

Cummins Inc., an Indiana-based diesel engine maker, is expanding its additive manufacturing portfolio with an investment in metal 3D printing using binder jet technology by Cummins' strategic partner, GE Additive. Binder jetting involves moving a print head across a bed of powder, while at the same time selectively depositing a liquid agent in the desired shape into the powder. This method of 3D printing can print parts 60 to 100 times faster than processes that are laser-based, depending on how complex the final product is. Teams from Cummins will be co-located at GE Additive's Cincinnati lab in order to work together on technology development. Later in 2019, the 3D printers will be relocated to one of the company's own facilities. This investment will assist toward scaled additive manufacturing production.

**I4MS announces €300k in EU funding to bolster 3D printing for SMEs**

The Innovation for Manufacturing SMEs (I4MS) program has announced the availability of €300,000 in EU funding to accelerate the competitiveness of small and medium-sized businesses in the 3D printing sector. The funding will be allocated based on an AMable call, which invites SMEs from across Europe to submit "proposals that bring forward an innovative idea of functional products that needs Additive Manufacturing." I4MS is a European Commission-backed program that is aimed at promoting and expanding digital innovations within the manufacturing sector, and specifically for SMEs. The newly released funding will bolster this effort.

**University of Sheffield joins €17 million INTEGRADDE project to accelerate industrial additive manufacturing**

Researchers from the University of Sheffield have joined the INTEGRADDE project, a €17 million European consortium developing end-to-end solutions for Directed Energy Deposition processes in metalworking industries. The INTEGRADDE project or "Intelligent data-driven pipeline for the manufacturing of certified metal parts through Direct Energy Deposition," is led by Spain's AIMEN Centro Tecnológico and includes 26 partners from 11 countries. Three engineering departments at the University of Sheffield are now supporting the project.

**Germany's Henkel acquires Molecule Corp., strengthening 3D printing & materials division**

Henkel purchased Concord-based Molecule Corp., adding to its technology-based portfolio and fortifying its additive manufacturing processes for production of strong, functional parts made from a variety of materials. The technology and expertise built thus far by the Molecule Corp. team will also complement Henkel's current strategies for research and development of new materials and techniques such as inkjet printing.

**Cummins Inc. invests in binder jet 3D printer, progress report on GE Additive H2**

Cummins Inc., a U.S.-based manufacturer and remanufacturer of engines, invested in a beta-stage H2 binder jet metal 3D printer from GE Additive. The technology will potentially provide Cummins' customers with faster, lower-cost and limited-energy-usage production. Currently, Cummins' Research and Development Center in San Luis Potosi, Mexico, has three 3D printers, and Cummins Technical Center in Columbus houses the Concept Laser M2 metal 3D printer by GE Additive. Furthermore, as part of the CTC's Materials Laboratory, the center has a dedicated Additive Manufacturing Laboratory.

**Carbon receives $260 million in additional funding for advanced development facility & international expansion**

Carbon plans to expand its operations considerably, along with strengthening its role as a player in the Asian and European 3D printing markets, following a $260 million growth round co-led by Madrone Capital Partners and Baillie Gifford. New investors Temasek and Arkema joined existing investors, including Sequoia Capital, Johnson & Johnson Innovation, Fidelity Management & Research Company, Adidas Ventures and JSR Corporation. With the most recent round, its cumulative funding totals $680 million. Marketing internationally, as well as acting through its new Advanced Development Facility, will strengthen Carbon's platform and workflow.

## Miscellaneous Partnerships

**ExOne partners with Sandvik to advance binder jet 3D printing technology using metal powders**

Industrial 3D printer provider ExOne will collaborate with Sandvik Additive Manufacturing to advance its binder jet 3D printing process. The companies will work toward optimizing the use of metal powders with binder jet 3D printing, with ExOne aiming to offer its industrial customer base an improved binder jet processing solution with the collaboration. The collaborative program will center on qualifying and optimizing Sandvik's Osprey metal powders with ExOne's binder jetting machines. The companies will study how the powder and binder jetting technology interact with one another, as well as developing the 3D printing process settings. Furthermore, ExOne and Sandvik Additive Manufacturing will create post-processing heat treatments for stainless steels, tool steels and nickel alloys, before moving on to various other materials.

**Desktop Metal partners with world's largest metal injection molding component producer**

Detroit-based metal 3D printer manufacturer RAPID + TCT will collaborate with metal injection molding specialist Bangalore-based Indo-MIM. The partnership will allow Indo-MIM to use the Desktop Metal Production System to become a full-service manufacturing partner for Desktop Metal. The first Desktop Metal Production System will be installed at Indo-MIM's San Antonio, TX, factory in summer 2019, becoming available to customers later in 2019.

**Impossible Objects partners with BASF for composite 3D printing**

Impossible Objects will partner with BASF on polyamide 6 (PA6) carbon fiber composites for additive manufacturing. Through a collaboration with BASF, Impossible Objects' Model One and CBAM-2 printers will support BASF's Ultrasint PA6 powder, allowing customers to 3D print high-performance carbon fiber/PA6 composite parts for the first time. Carbon fiber/PA6 composites will offer better strength and temperature performance at a lower cost than PA12, and they are up to four times stronger than parts made via conventional fused deposition modeling (FDM) and twice as strong as those made via multi jet fusion (MJF) parts. PA6 adds to Impossible Objects' currently supported materials and will be available for shipment in the third quarter of 2019.

**Lincoln Electric acquires Baker Industries for additive manufacturing business launch**

Lincoln Electric Holdings, Inc., an American multinational manufacturer of welding products, will launch a metal additive manufacturing service in mid-2019 following its acquisition of Michigan-based tooling supplier Baker Industries, Inc., which provides polymer and metal additive manufacturing capabilities, alongside traditional machining and fabrication.

**ExOne and ORNL collaborate to develop new binder jet 3D printing technology**

Industrial 3D printer supplier ExOne will collaborate with Oak Ridge National Laboratory (ORNL) to advance binder jet 3D printing. The aim of the collective is to develop a new binder jet technology benefiting both sand and metal 3D printers. In the first stage of ExOne's and ORNL's undertaking, the teams will be working to optimize chemistry and process parameters for ExOne sand and metal 3D printers. In the second stage, discoveries gained from this development will be used to help process H13 Tool Steel. As a versatile alloy, H13 is commonly used in tooling and die industries. It is resistant to thermal cracking when worked at elevated temperatures and has a high toughness. Other 3D printer OEMs have also recently been developing their own H13 feedstocks.

**Origin and DSM announce partnership to develop new open additive materials**

Royal DSM, a global science company and material manufacturer, partnered with 3D printing startup Origin. The goal of this collaboration is to develop new materials for additive manufacturing, and marks another boost for Origin's Open Additive Production platform. The two will focus on the optimization of Royal DSM photopolymer materials for Origin's programmable P3 3D printing platform. The first material to be developed under the DSM partnership is Somos PerFORM HW, a composite material optimized for Origin's P3 technology.

**HP launches 5200 series of 3D printers, forms strategic alliances with industry**

HP launched a new line of Jet Fusion 3D printers, which will target volume production, with accuracy and repeatability likened to injection molding. As part of a four-part announcement, the company also released a new flexible TPU for Jet Fusion, confirmed new industrial alliances with Siemens, BASF and Materialise, and introduced its Digital Manufacturing Network. Siemens and HP will develop a joint solution for applying additive manufacturing in industrial and automotive environments. With BASF, HP has been developing new application-driven materials for Jet Fusion technology. With Materialise, HP will be integrating the 5200 series within the Belgian company's Build Processor and Magics 3D Print Suite. Finally, the HP Digital Manufacturing Network was founded with members including Forecast 3D, GKN Powder Metallurgy, GoProto, Jabil, Materialise, Parmatech and ZiggZagg NV. As members, these companies have been qualified by HP to produce 3D printed parts using Jet Fusion and/or Metal Jet technology. More partners are expected to join this network in the coming months. Presently, the HP Digital Manufacturing Network covers the U.S., Asia and Europe.

**Adaptive3D partners with DSM to commercialize Soft ToughRubber 3D printing resin**

Texas-based 3D printing resin specialist Adaptive3D partnered with Dutch nutrition and DSM to commercialize a resin-based soft rubber-like material. The material will be sold under the name Soft ToughRubber. The Soft ToughRubber will have a wide variety of uses in the consumer industry, in applications such as wearables, textiles, electronics, as well as specialist uses like anatomical models.

## Patents & Copyright

**Poietis granted European patent for laser-assisted 3D bioprinting**

Poietis, a French biotechnology company, has been granted a third patent for its laser-assisted 3D bioprinting method. With five years of experience in the medical field, Poietis' 3D bioprinting technology presents a novel process of developing realistic self-organizing cell structures. Unlike conventional approaches to tissue engineering or extrusion bioprinting, laser-assisted bioprinting allows cells to be positioned in three dimensions with micrometric resolution and precision. Its technology is being implemented in cosmetics to fabricate skin models, through a partnership with BASF.

## Auto & Transportation

**Arrow Schmidt Peterson Motorsports races ahead with Stratasys 3D printing**

Stratasys signed a deal with NTT IndyCar Series competitor Arrow Schmidt Peterson Motorsports. The agreement sees the professional racing team integrating Stratasys' Fortus 450mc and F370 3D printers for the production of functional prototypes, tools and end-use components for its race cars. Stratasys' technologies and additive manufacturing are typically finding their place within the motorsports industry.

**Tunisian researchers 3D print optimized car leaf spring out of carbon PEEK**

Tunisian researchers optimized the design of a carbon leaf spring from a Dodge SUV. The researchers used a custom-made FFF ARGO 500 Roboze 3D printer to produce the parts, outfitting it with a chassis meant to prevent excess vibration, along with chrome-plated internal fittings. Future works will present the dynamic analysis and its behavior of the leaf spring under dynamic loading conditions.

## Aviation & Aerospace

**NASA and TTH use Carbon 3D printing to create Seeker spacecraft inspection robots**

The Technology House, a product development service provider, used Digital Light Synthesis 3D printing technology from Silicon-valley based Carbon to help produce autonomous robotic systems as part of the SEEKER project for NASA. Costing $3 million, the SEEKER project is composed of two free-flying autonomous robots, Seeker and Kenobi, designed to inspect and monitor such craft while in space. Seeker and Kenobi were launched aboard the Cygnus spacecraft from Northrop Grumman, a commercial partner of NASA, as part of the first demonstration of the free-flyer technology for autonomous robotic inspection from NASA. TTH used Carbon's M2 3D printer in conjunction with Cyanate Ester 221 to produce four high-performance thrusters for the cold-gas propulsion system within the Seeker robots for NASA. The SEEKER project contains the "first certified plastic additive manufactured parts in actual space."

**Auburn University receives NASA contract to develop 3D printing techniques to improve liquid rocket engines**

Auburn University's Samuel Ginn College of Engineering announced that NASA awarded a three-year, $5.2 million contract to NCAME to research and create 3D printing techniques to help improve the performance of liquid rocket engines. The work covered under the contract is part of NASA's Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) project, and is the latest development to result from Auburn University's relationship with NASA's Marshall Space Flight Center. RAMPT is centered around evolving lightweight, large-scale novel and 3D printing techniques for developing and fabricating regeneratively cooled thrust chamber assemblies for use in liquid rocket engines.

**NASA is using 3D printing to develop soft robots for space exploration**

Chuck Sullivan and Jack Fitzpatrick, interns at NASA's Langley Research Center in Hampton, VA, are investigating the viability of using soft robotics for space exploration and assembly. Soft robots are constructed from highly flexible materials, allowing for new robot movements similar to living organisms that traditional robots can't replicate, therefore presenting new possible applications for robots in space. The pair anticipate they can develop soft robots to be used in space where they can help keep astronauts safe and productive.

**Boom Supersonic working with VELO3D to make metal 3D printed hardware for supersonic flight demonstrator**

Colorado-based Boom Supersonic, which is working to build the fastest supersonic airliner in history, and metal 3D startup VELO3D will partner to develop Boom Supersonic's 55-seat, Mach-2.2 aircraft. Boom is using VELO3D's Intelligent Fusion technology to make the metal flight hardware for the jet, as it offers more design freedom, process control and quality assurance; these qualities are essential in challenging design environments. Boom is also working with VELO3D in order to leverage its customer support partnership, market expertise and ability to guarantee consistent production quality.

**CRP Technology and Polimi 3D team up to 3D print wind tunnel model parts**

CRP Technology collaborated with the Department of Aerospace Science and Technology of the Politecnico di Milano to construct wind tunnel aero-elastic demonstrators. As part of the partnership, CRP has provided its 3D printing expertise and own brand composite material to support PoliMi's "Aeroelastic Flutter Suppression (AFS)" and "GLAMOUR" projects. 3D printed aerodynamic sections of the wings produced for the project have thus far successfully passed the control and testing criteria, and have fully complied with the requests and PoliMi's standards.

**Marshall ADG to 3D print functional aircraft parts with Stratasys Fortus 450mc**

Marshall Aerospace and Defence Group, a U.K.-based aircraft design and maintenance company, is using a Stratasys Fortus 450mc to build tooling, functional and prototyping parts for aircraft. Marshall ADG will use the engineering-grade ULTEM 9085 resin, which is tough, yet lightweight, 3D printing material with high thermal and chemical resistance. The team considers this development as "crucial to overcoming the stringent requirements of our industry," as Marshall ADG is now able to "print parts with the desired flame, smoke and toxicity properties for use on aircraft interiors."

**Relativity Space to build autonomous rocket 3D printing factory in Mississippi**

Relativity Space has been granted permission to expand facilities at NASA'S Stennis Space Center in Hancock County, MS. In agreement with NASA and the Mississippi Development Authority, the company will have exclusive use of up to 220,000 square feet of space to build a robotic 3D printing factory and test facility for the Terran 1 rocket. By completion, Relativity expects to create 200 jobs at the Stennis site, and will invest $59 million in the state of Mississippi. Looking to expand Stennis' facilities, the Mississippi Development Authority provided Relativity with an incentive package for the move. The integration of its 3D printing rocket production and testing facilities at one site will also enable relativity to offer greater flexibility to commercial and government entities needing faster, more frequent and lower cost access to space.

**NASA backs demo that will 3D print spacecraft parts in orbit**

To expand its efforts to bring 3D printing to space, NASA gave Made in Space a $73.3 million contract to demonstrate the ability to 3D print spacecraft parts in orbit using Archinaut One, a robotic manufacturing ship due to launch in 2022 or later. The vessel will fly aboard a Rocket Lab Electron rocket and 3D print two 32-foot beams on each side with two solar arrays. The completed arrays could produce up to five times more power than the solar panels normally found on spacecraft this size. This is the start of a second phase of a partnership between the two companies.

**Rolls-Royce to 3D print aerospace parts with SLM 500**

Rolls-Royce, a British manufacturer and distributor of power systems for aviation and automotive industries, has announced plans to 3D print aerospace parts with SLM Solutions' quad-laser technology. The company is also joining SLM's beta customer program for future developments. With the new partnership, the Rolls-Royce team can document its expertise and control of the systems adhering to strict regulations and keep its ambitious and innovative additive production plans on track.

**Burloak Technologies and Safran partner to 3D print landing gear parts**

Canadian metal 3D printing service bureau Burloak Technologies has signed a Memorandum of Understanding with France's Safran Landing Systems. The two companies will use DED technology to manufacture components of aircraft landing gear systems. In addition to this, Burloak has also partnered with the National Research Council of Canada (NRC). The agreement gives Burloak access to NRC's patented research to develop a Directed Energy Deposition (DED) system. With the help of NRC, Burloak will expand its portfolio with the inclusion of a multi-axis DED-based system.

## Health & Life Sciences

**Orgenesis announces collaboration with Digilab to develop industrial 3D printing capability for cellular structures and tissues for clinical use**

Orgenesis, a developer, manufacturer and service provider of advanced cell therapies, will collaborate with Digilab to develop a live cell printing process and systems designed to automate the production of 3D live cellular structures and tissues. Orgenesis will have the exclusive rights to codevelop the process and systems required for its therapeutic collaboration programs and to utilize, market and distribute the new cell printer systems and related products. The systems will incorporate Digilab's proprietary synQUAD liquid dispensing technology, offering both on-the-fly and drop-by-drop, non-contact, cell printing while maintaining the viability of even the most delicate cells. The industrial process capability to be codeveloped by Orgenesis and Digilab is designed to provide closed-loop systems and solutions for culturing and printing a variety of cells, with the initial focus on liver and liver-derived cells for autologous clinical applications for point-of-care processing services.

**Researchers 3D print new body parts for athletes**

Researchers from Rice University and the University of Maryland detail their efforts to engineer an implant that would replicate the body's osteochondral tissue, which is found at the end of long bones. Because the tissue's consistency changes, transitioning from cartilage to bone, bioengineers have had trouble mimicking it. The Rice and UMD researchers used different materials to 3D print each part of their osteochondral tissue scaffold: a polymer mixture for the cartilage and a ceramic for the bone. The researchers also added pores to the scaffold that the patient's own cells and blood vessels could infiltrate. This would allow the implant to seamlessly merge with the recipient's natural biology, helping heal the injured bone and cartilage if a patient has suffered an osteochondral injury.

**Researchers claim they've 3D printed artificial heart using patient's cells**

Researchers at Tel Aviv University 3D printed a small heart, the approximate size of a rabbit's, complete with muscle and blood vessels. The living heart's cells originated from a single human donor's fat tissue, which were subsequently transformed into stem cells and differentiated into various cell types in the heart. Those cells were then printed into a biodegradable scaffold, or skeleton, that gives it its shape. The technique may lead to transplants in which organ rejection is significantly reduced. However, while it looks like a heart, structurally it's not yet functional and doesn't pump. The more immediate value of the Israeli work is to make what they call a cardiac patch, a piece of functioning heart tissue to repair heart attack damage. The first printed organs and tissues for actual human use will be simpler: bladders, ears, blood vessels and windpipes, some of which have already been implanted in patients

**Virginia Tech researchers find new way to 3D print prosthetics with integrated sensors**

Bake Johnson, an assistant professor in industrial systems and engineering from Virginia Tech, and a team of undergraduate students are hoping to advance customized 3D printed prosthetics with the integration of electronic sensors. The project aims to make sophisticated, electric-powered prosthetics more accessible than existing state-of-the-art prosthetics. The research project marks a step ahead in the evolution of 3D printed prosthetic systems by improving their functionalities through the integration of sensors. The sensors in question are placed at the intersection of the prosthetic and the wearer's tissue and are capable of gathering information related to comfort and function.

**U.K. researchers 3D print scaffolds enabling bone regeneration for fractures in horses**

Scientists from the U.K.'s Animal Health Trust and the University of East Anglia are using 3D printed scaffolds to support bone regeneration in horses. Using BendLay Polycarbonate filament, 3D printed scaffolds were produced that can turn induced Pluripotent Stem Cells (iPSC), derived from skin or blood cells, into bone forming cells. Using the MakerBot Replicator 2 3D Printer, two scaffolds were produced with fine mesh (150 µm pore size) and then cultured with cells. The team found that the fine mesh layer of the scaffolds retained the cells effectively.

**Bioengineers 3D print complex vascular networks**

A team led by Rice University and the University of Washington has developed a tool to 3D print complex and "exquisitely entangled" vascular networks. These mimic the body's natural passageways for blood, air, lymph and other fluids, and they will be essential for artificial organs.

**Engineers 3D print flexible mesh for ankle and knee braces**

MIT engineers have designed pliable, 3D printed mesh materials whose flexibility and toughness can be tuned to emulate and support softer tissues such as muscles and tendons. They can tailor the intricate structures in each mesh, and they envision the tough yet stretchy fabric-like material being used as personalized, wearable supports, including ankle or knee braces, and even implantable devices, such as hernia meshes, that better match to a person's body. This research was supported in part by the National Science Foundation, the MIT-Skoltech Next Generation Program, and the Eric P. and Evelyn E. Newman Fund at MIT.

**Scientists 3D print biological tissue without using scaffolds**

A team at the University of Illinois at Chicago, led by Prof. Eben Alsberg, has developed a system that uses a block of hydrogel made up of microscopic beads. A printing nozzle is lowered into that gel, where it moves back and forth depositing a "bioink" consisting of stem cells. That bioink is held in place by the microbeads, staying where it was deposited within three-dimensional space. The team demonstrated the call aggregates "can be organized and assembled using this strategy to form larger functional tissues, which may be valuable for tissue engineering or regenerative medicine, drug screening and as models to study developmental biology."

**Structo and uLab team to 3D print dental aligners**

Singapore-based dental 3D printer OEM has partnered with California-based digital dentistry company uLab Systems to streamline the production of orthodontic clear aligners. The collaboration will integrate Structo's dental-specific DentaForm 3D printer with uLab's uDesign aligner treatment planning software, enhancing uLab's uPrint ecosystem. Currently, these processes are done manually; by automating these it will lower the cost and reduce manufacturing errors and inconsistencies.

**T&R Biofab and SCM Life Science partner to 3D print regenerative tissue**

Korean biotechnology companies T&R Biofab and SCM Life Science are to collaborate on the R&D of new 3D printed tissue regenerative products. The two companies will focus on marketable cell patch products and new formulations for cell therapy. T&R Biofab will also gain access to bioink material suitable for tissue fabrication, good manufacturing practice-based cell production system, and good laboratory practice-based safety evaluation system.

**Florida researchers develop bioink to 3D print human cornea**

Researchers from Florida A&M University developed a bioink and 3D printed a human cornea that they believe could lead to significant advancements in the medical field. By 3D printing a cornea that contains similar materials to a real cornea, the team realized that the development may reduce the need for animal testing for eye products such as gels and drops. The team is now working on creating a blinking eye model, which would be used for an in vitro model to help understand the permeation of drugs in other research.

**Smile Direct Club partners with HP to make 50,000 3D printed molds per day**

Smile Direct Club will use HP's Multi Jet Fusion 3D Printing technology to produce Invisalign dental aligner molds. SmileDirectClub will use 49 HP Jet Fusion 3D printers for manufacturing. The printers will produce over 50,000 molds a day. This makes SmileDirectClub one of the largest users of HP systems worldwide. The company is on track to produce 20 million 3D printed molds over the next year.

**Korean researchers 3D print biocompatible human cornea**

Engineers from Pohang University of Science and Technology in South Korea have replicated a structure of the human eye by 3D printing an artificial cornea. The team collaborated with a range of scientists from across the country, including Kyungpeok National University School of Medicine, to 3D print the experimental cornea using a bioink made of decellularized corneal stroma and stem cells.

## Manufacturing & Construction

**3D printed bathroom units take shape in a single day**

Researchers at Nanyang Technological University in Singapore developed a new proof-of-concept bathroom unit that can be 3D printed in its entirety in a single day. The process involves a specially developed concrete mix, which includes eco-friendly materials including geopolymers made from fly ash waste. The concrete remains watery enough to be properly distributed through the hoses and nozzle of the 3D printer, but is able to harden quickly enough for the machine to apply another layer on top of it not long after. The approach results in a material and weight saving of up to 30% and takes around half the construction time of typical prefabricated bathrooms made with concrete casting. The team is working on gaining approval from the relevant building authorities to trial the technology and are also looking to commercialize it through a spin-off company.

**Concreative: VINCI launches construction 3D printing startup in UAE**

VINCI Construction, a France-based construction leader, is launching a new company, Concreative, focused on 3D printing high-performance concrete materials through its subsidiary Freyssinet. Concreative will offer a fully integrated service, providing support from early design stages to on-site installation. Concreative will utilize construction 3D printing technology developed and patented by French company XtreeE.

**CyBe Construction selected to 3D print houses in Sharjah, UAE**

CyBe Construction, a Netherlands-based concrete 3D printing specialist, has been selected as the technology provider for a 3D printed house project in the UAE. The house will be built as part of the Sharjah Research, Technology and Innovation Park (SRTI Park) initiative, which aims to 3D print a series of buildings in the area with the goal of transforming the city of Sharjah into an architectural hub. The first 3D printed house of the SRTI Park project, supported by CyBe and the American University of Sharjah (AUS), is expected to be built by Q3 2019. The house will be constructed using CyBe 3D printing construction technology with the help of students, faculty and researchers from AUS, who will be trained in using the additive manufacturing platform.

**Schunk adopts Anisoprint composite 3D printing for metal part replacement**

Schunk Carbon Technology, a German manufacturer of additive carbon and ceramic construction components, has adopted Anisoprint composite 3D printing technology. Anisoprint's system, the Composer, will be used to accelerate the development and production of custom tools used in high-temperature applications, as well as the automotive and small motor sectors. The Composer integrates a composite reinforcing fiber, made of thousands of ultrathin carbon monofilaments, into a plastic. This improves adhesion between the polymers and the fiber. The company claims that these 3D printed parts are 25 times stronger than pure plastic and seven times lighter than steel.

## Clothing & Wearables

**USC electric field 3D printing method makes graphene smart armor**

Researchers from the University of Southern California are using 3D printing to investigate the potential of smart metamaterials. Adding the brick-and-mortar structure of high-strength nacre to electrically conductive graphene, the team has demonstrated the ability to create self-sensing armor. The process could be used to monitor damage to the body. Linked up to a small red LED, a 3D printed helmet developed by the USC team is designed to "sense" pressure from above. As compression increases, the intensity of the light decreases, signalling its potential to crack. Finally, when the helmet is forced to crack, the LED switches off, alerting failure of the device. Such a system could be used as a preventive measure for the failure of sportswear, armor and even certain components.

**3D printing steps out in style at New York's Met Gala**

At the annual Met Gala, with the theme of "Camp," American fashion designer Zac Posen collaborated with GE Additive and Protolabs to provide several 3D printing outfits to the event. One entirely 3D printed bustier dress was inspired by the look of Cinderella's glass slipper, which took Protolabs over 200 hours to complete. Another piece was composed of 21 individual petals, 3D printed in Accura Xtreme White on 3D Systems' SLA machines at Protolabs. Each petal, which individually took 100 hours to print, is also fastened by a custom metal cage 3D printed on a GE Additive Arcam EBM machine. A headpiece was 3D printed as a single piece using HP Multi Jet Fusion technology, and Indian film actor Deepika Padukone's dress featured 408 3D printed and embroidered floral embellishments. Posen's garments were made under his fashion brand House of Z. The majority were made at Protolabs facilities in Raleigh, North Carolina, with Canadian actor Nina Dobrev's bustier dress 3D printed at Protolabs in Germany, and the metal frame of British model Jourdan Dunn's rose gown made at the GE Additive Technology Center in Cincinnati.

**New Balance and Formlabs launch TripleCell 3D printing platform and rebound resin for athletic shoes**

New Balance launched a new premium 3D printing platform, TripleCell, which is powered by SLA technology from Formlabs and a new material. The two companies intend to focus on creating high-performance hardware and materials, in addition to a manufacturing process for athletic footwear. They wanted to create a 3D printing production system with design freedom that would open up opportunities for innovation in the athletic footwear sector. The new TripleCell platform can deliver components that are close to traditional performance cushioning, thanks to the proprietary photopolymer Rebound Resin that was developed as a result of the partnership. Rebound Resin has a higher tear strength, energy return and elongation than any other Formlabs SLA material.

## Food

**Heineken embraces Ultimaker 3D printing technology**

Heineken is using Ultimaker S5 3D printers to produce functional end-use parts for its beer production line in Seville, Spain. Heineken is now able to print its own parts on-demand, in the process reducing the need for outsourcing, potentially increasing production uptime, and saving approximately 80% in production costs. As the successful experimental phase draws to a close in the Seville brewery, Heineken hopes to start up multiple projects to apply these functional applications and scale them to its global operation.

## Education

**MakerBot expands educational ecosystem with MakerBot Certification Program for Students**

MakerBot, an American desktop 3D printer manufacturer and Stratasys subsidiary, launched the MakerBot Certification Program for Students to provide middle and high school students with 3D printing design and training. The launch of the new scheme expands upon the existing International Society for Technology in Education-approved MakerBot Certification Program for Educators. The MakerBot Certification Program for Students joins various other initiatives established by 3D printing companies to help integrate 3D printing in education and enhance the STEAM/STEM curriculum. This includes some from MakerBot itself, beyond the Certification Program.

## Arts & Entertainment

**American Magic adopts Stratasys carbon fiber 3D printing for America's Cup**

American Magic, a New York Yacht Club challenger for the 36th America's Cup, is furthering its use of 3D technologies to gain a competitive edge in the world-renowned sailing competition. It recently utilized Creaform's 3D scanning to simulate and verify boat components. Currently, it entered a supplier agreement with Stratasys for carbon fiber parts. The sailing team is hoping to leverage the benefits of Stratays' Fortus 450mc 3D printer and its capabilities to print carbon fiber reinforced Nylon 12. Working with Stratasys, the team will evaluate and integrate 3D printed final parts into its competitive sailing yacht. The technology will enable the team to 3D print parts when necessary and reengineer new parts after each qualifying race to improve performance.

**3D printing turns heavy metal: Rock legend Yngwie Malmsteen fails to break Sandvik's smash-proof 3D printed guitar**

Swedish manufacturing group Sandvik has produced the "world's first smash-proof 3D printed guitar." Featuring a 3D printed titanium body and a neck supported by Sandvik's hyper-duplex steel technology, this instrument has a super strength proven to have rock legends beaten. In a test following a live performance, playing the guitar, heavy metal electric guitarist Yngwie Malmsteen was unable to leave even a dent in its case. Sandvik employed the skills of renowned guitar designer Andy Holt of Drewman Guitars to help design the instrument.