Issue 6 | 2022/Q4

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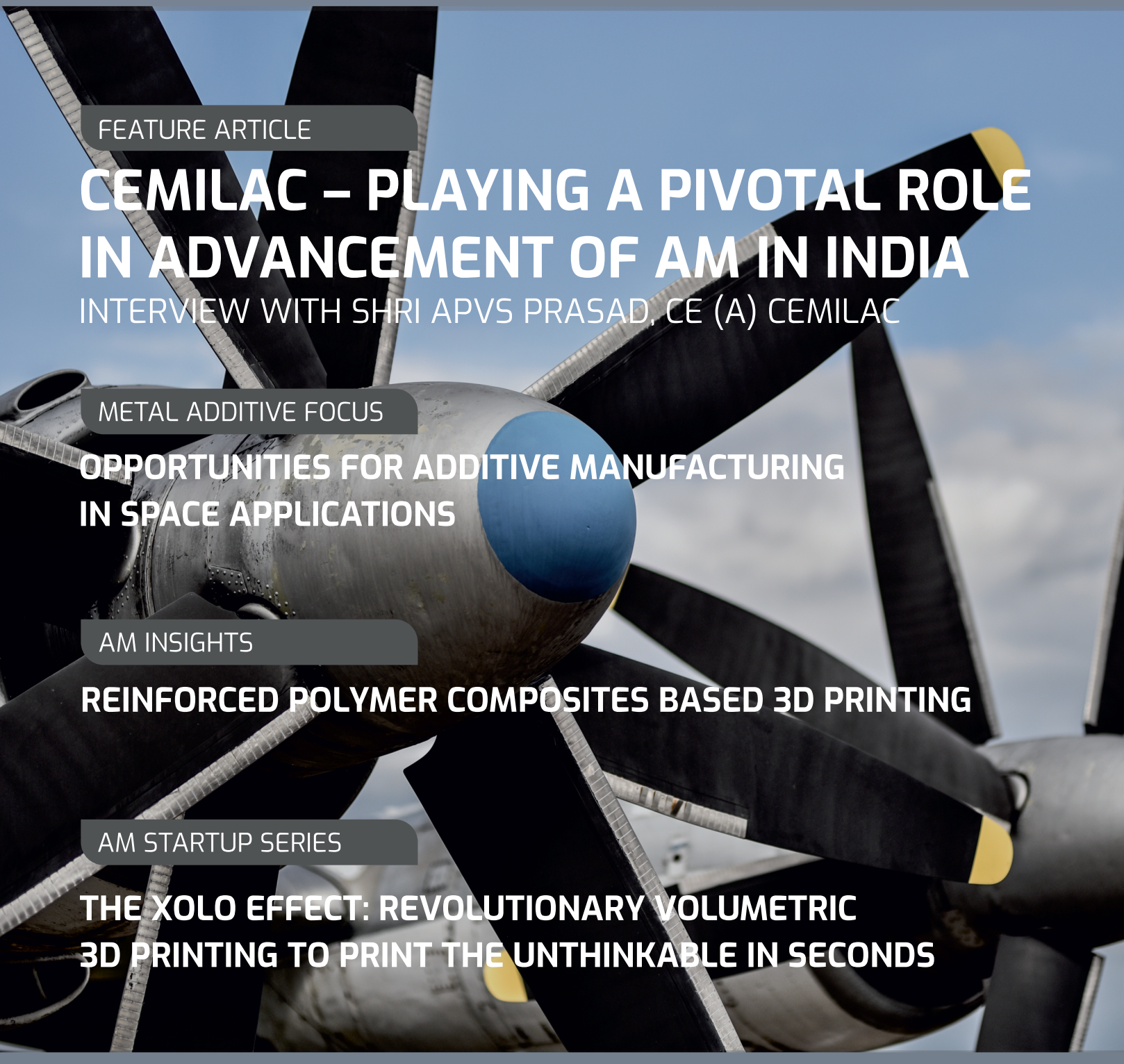

FEATURE ARTICLE

CEMILAC – PLAYING A PIVOTAL ROLE IN ADVANCEMENT OF AM IN INDIA

INTERVIEW WITH SHRI APVS PRASAD, CE (A) CEMILAC

METAL ADDITIVE FOCUS

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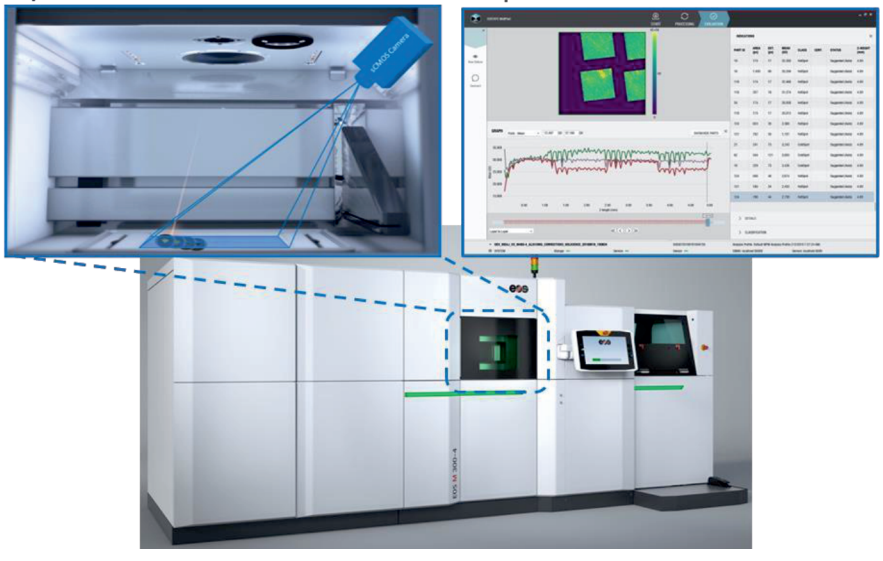

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EDITORIAL

Additive Manufacturing in India – Now or Never !

The Additive Manufacturing ecosystem is fast changing in India, as much as the rest of the world. While quite a few challenges still lie ahead for accelerating the adoption of Additive Manufacturing in India, a common consensus is building in the industry, academia, government and defense establishment on the importance of this technology.

One of the major challenges which need to be addressed immediately is the silo approach which is currently prevalent in India across different organizations, industry bodies, institutes, government initiatives, etc. There is an urgent need for all the stakeholders to work together collaboratively towards a brighter and efficient future for Additive Manufacturing in India.

Some of you who are reading this issue are perhaps present at AMTECH. This is a humble attempt we are making to provide a neutral and conducive platform for the industry and the various other important stakeholders to come together at one place to learn, explore, discuss strategies and chart out the roadmap for Additive Manufacturing in India. AMTECH, thanks from the support from the industry and our partners has grown this year with 70+ exhibitors and 150+ solutions, where the potential end use industries can experience the entire ecosystem of 3D Printing and Additive Manufacturing at one place. This reflects the growth and intent of the Indian AM ecosystem.

Our feature articles in this issue share insight into the approach CEMILAC is taking to curtail certification time for AM and the AMTECH preview. This issue also covers topics ranging from Polymer Additive Manufacturing, Case Studies, Standards, Metal Additive Manufacturing, Composite 3D Printing, AM Startup series and more.

We always at the forefront with our efforts and keen to play our part in unlocking the true potential of Additive Manufacturing in the region.

Aditya Chandavarkar
Co-Founder - AM Chronicle

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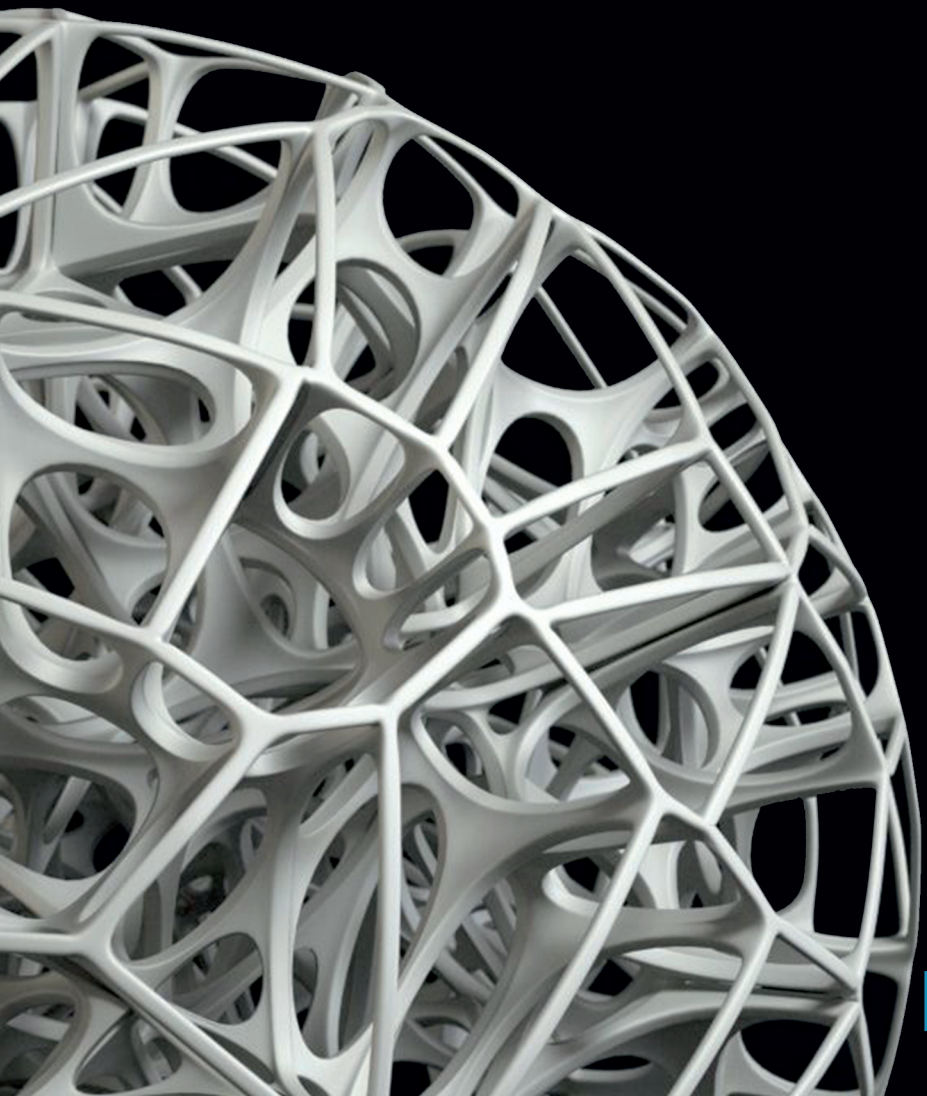

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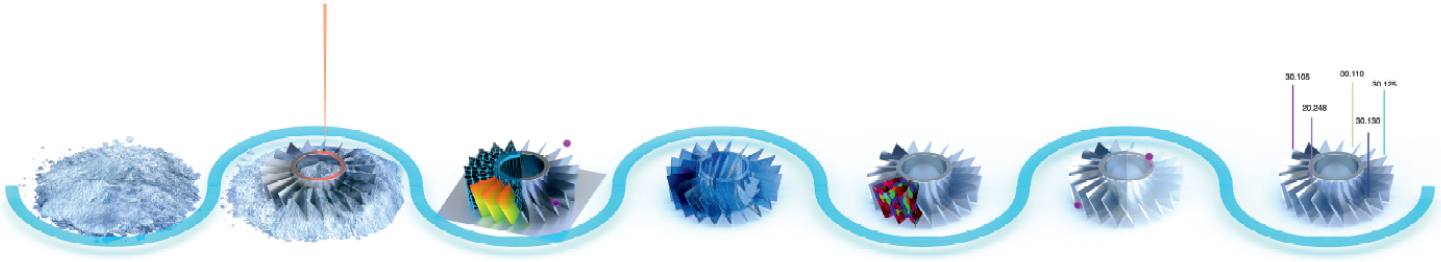

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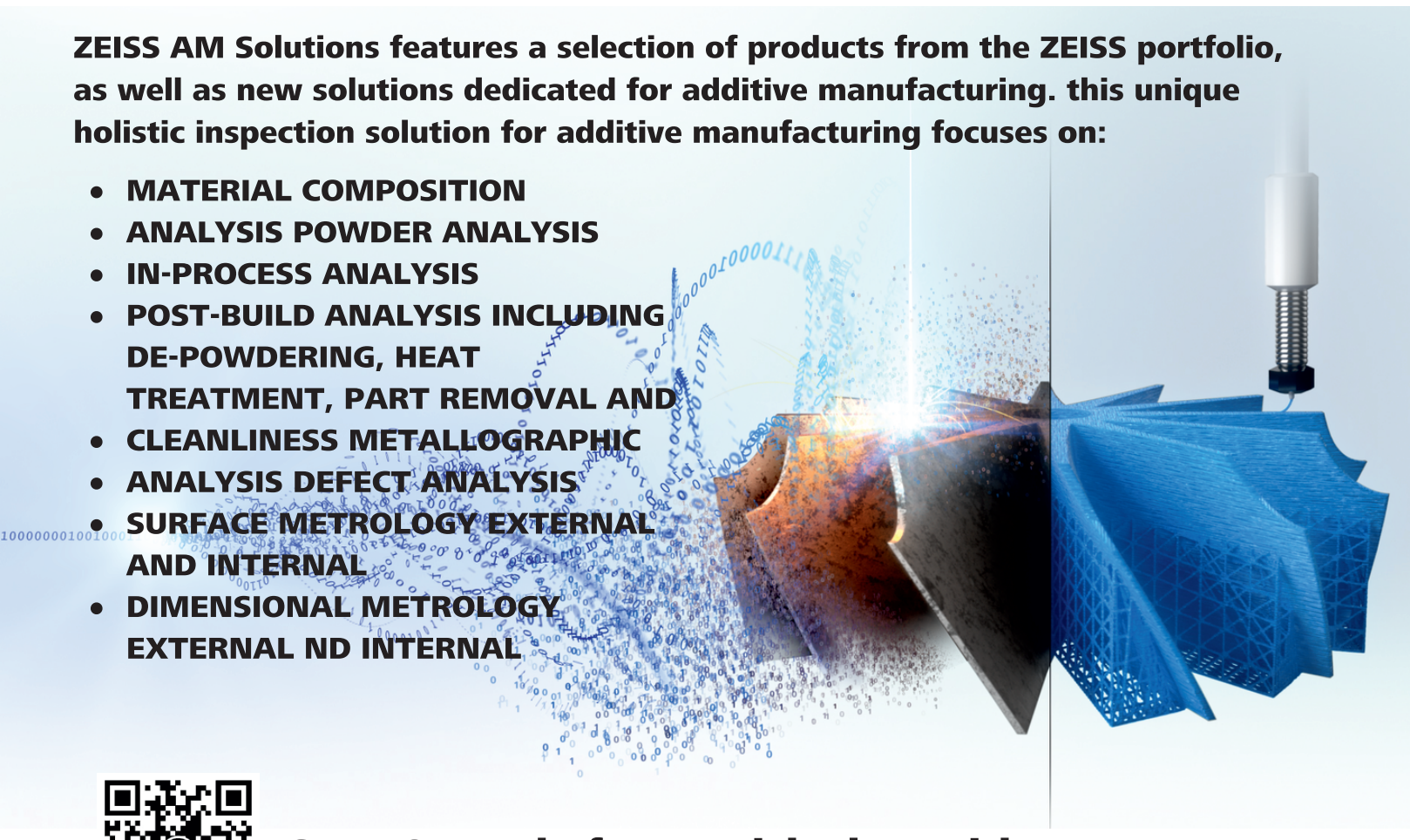

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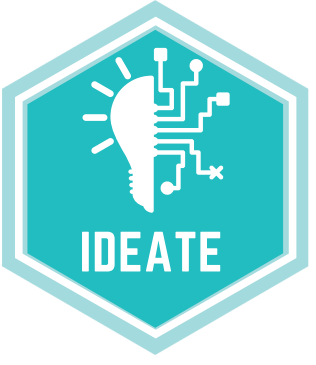

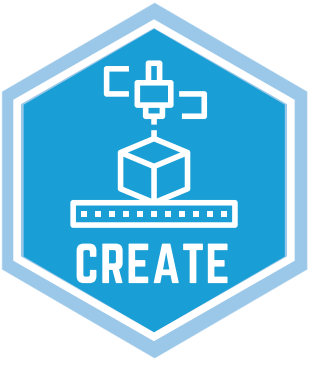

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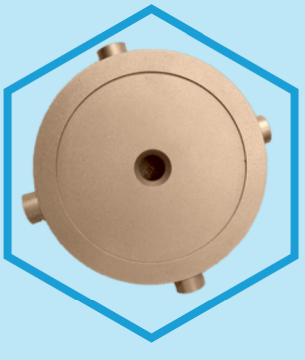

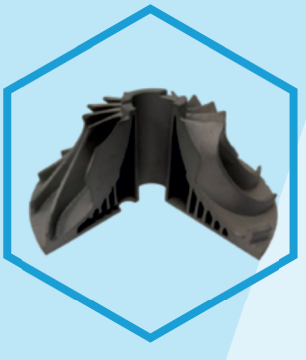

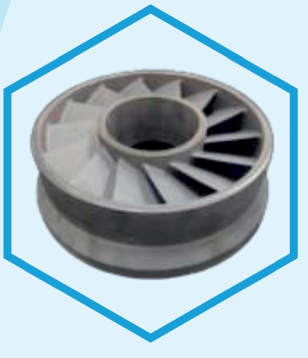

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CEMILAC – Playing a Pivotal Role in Advancement of Additive Manufacturing in India – Interview with Shri APVS Prasad, CE (A) CEMILAC

Aditya Chandavarkar

In this interview, Shri APVS Prasad, Head of the Centre for Military Airworthiness and Certification (CEMILAC), discusses the opportunities for Additive Manufacturing in defense and the role of CEMILAC in the certification of AM parts.

Additive Manufacturing is moving at a fast place globally and it is providing defence forces an opportunity to have control over their supply chains for components, new product development and obsolescence management. India is also making rapid strides in adoption of Additive Manufacturing for defence requirements and CEMILAC is playing a pivotal role. To find out more about the current scenario, Aditya Chandavarkar, Managing Editor, AM Chronicle had the privilege to have an exclusive interaction with Shri APVS Prasad, Chief Executive (A), CEMILAC.

Shri APVS Prasad, heads the Centre for Military Airworthiness and Certification (CEMILAC), Department

of Defence R&D, Ministry of Defence as its Chief Executive (A). He is an alumnus of Osmania University, Hyderabad and obtained B.E degree in Electronics and Communication Engineering in the year 1989. Subsequently he pursued higher studies and acquired M. Tech in Telecommunications, from IIT Kharagpur during the year 1997.

(L to R) Shri APVS Prasad, CE (A), CEMILAC;
Aditya Chandavarkar, Managing Editor, AM Chronicle

Shri APVS Prasad joined Aeronautical Development Establishment (ADE), DRDO in 1990 as a scientist and has close to 3 decades of experience in the research and development of Avionics Systems for Unmanned Aerial Vehicles. He has worked as Programme Director of Rustom –II UAV and it is under his able guidance that R-II was successfully flight tested. His areas of interest are Design and Development of Data Links, Avionics, Payloads, Software defined Radios, Altimeters and Doppler Radars.

He took over as Chief Executive (Airworthiness), Centre for Military Airworthiness and Certification (CEMILAC) on 31st May 2019. As CE (A), CEMILAC, he is spearheading the Airworthiness Certification of all development programmes of national importance viz., Military Aircraft, Helicopters, UAVs, Airborne Stores, Integration of weapons, Upgrade programs, Indigenization etc. As the head of 14 Regional Centres (RCMAs) spread all over India he is ensuring flight safety of all Military Airborne Vehicles / Stores of the nation.

Shri APVS Prasad has received many awards in recognition of his work in the development of UAVs. He was honoured with the DRDO 'Scientist of the year award' for the year 2016, 'Technology Group Award' for the year 2012 and also in 2017, CACE team award for the years 2009 and 2010 and 'DRDO team award' consecutively for the year 2004 and 2005.

He is a member of various prestigious professional bodies namely Institute of Electronics and Telecommunication Engineering, Aeronautical Society of India, Computer Society of India (ASCI). He is also a panel coordinator for ARDB System Engineering Panel.

Aditya Chandavarkar: What are the objectives of CEMILAC and how is this role changing with fast moving disruptive technology is being introduced for manufacturing?

Shri APVS Prasad: CEMILAC is an airworthiness certification body responsible for the military airsystem and airborne stores in the country. It is primarily intended for carrying out technical airworthiness activities during design, development and production of Air Systems and Airborne Stores. It also participates in ongoing airworthiness activities and issuing instruments of technical airworthiness approvals to ensure the aircraft's operational requirements and safety.

Recent PM's Atmanirbhar Bharat mandate has motivated CEMILAC to be proactive. CEMILAC has started its involvement in the beginning of the project rather than at the end of the product design development cycle, called as concurrent certification approach. In this approach, CEMILAC provides upfront support to the Indian private sector so that they are clear with the certification requirements in the beginning to avoid costlier design modification at the later stage.

As a matter of fact, our scientists have that unique

opportunity in the country to associate themselves with the best of the designers in the country and they have an excellent exposure to the various problems that a designer will face for certification. As a result, they share all of their knowledge with the new designers. That adds a lot of value to the entire certification process.

Aditya Chandavarkar: That's a great approach. and Additive manufacturing is one such technology, which is redefining manufacturing today. So what advantages do you think this brings to the Indian defence organizations?

Shri APVS Prasad: Additive manufacturing is growing in Indian Military Aeronautics. Our Indian Air Force is one of the most unique in the world, operating anywhere from 35 to 40 different types of aircraft from the various country origin. Hence, we have wide varieties of Ab-initio and MRO components to be indigenized.

The cost of producing the components through traditional manufacturing processes is high due to the high volume requirements. The additive manufacturing fills this void in a unique way. The turnaround time for indigenous AM is quite short, and the second benefit is the cost savings.

Aditya Chandavarkar: That's true, so at CEMILAC what strategies are you ensuring, So that additive manufacturing can be accepted as one of the technologies which can be utilized for component manufacturing.

Shri APVS Prasad: We have a very good team of people who are knowledgeable about additive manufacturing.

Our team have taken great initiative of interacting with all of the stakeholders (powder, machine and part) and created the synergy among them. This gave them the confidence that the certification is an easy process in India.

In addition, Contactless E-certification, a user-friendly website, and the development of an E- portal are other initiatives taken by CEMILAC that is expected to help development agencies immensely. With these initiatives, CEMILAC has shown a positive note of certification in India.

Aditya Chandavarkar: That is great to know that CEMILAC is walking extra mile to work with the industry as well. But specific again to additive manufacturing. What challenges are being seen, let's say on the material technology or testing agency which allows for further adoption?

Shri APVS Prasad: Time and money are major challenges in the AM technology. For example, the certification of single powder (Inconel 718) took about 8 months. There are several grades of powders, several types of AM processes. Once we certify a powder and process, we must also certify the component. It must go through the rigorous and time-consuming cycle of qualification tests. The investment for undertaking the qualification also adds to the investment.

Aditya Chandavarkar: What is the expectation from CEMILAC and the Indian defence from the Additive Manufacturing stakeholders from India?

Shri APVS Prasad: CEMILAC is the first certification body which has evolved the route to certification for additive manufacturing process and parts. This document covers qualification of powder and part comprehensively. In powders, CEMILAC has certified Inconel 718, a high-temperature engine material powder. In parts, CEMILAC has certified non-critical Al alloy fuel system components and mission critical steel inner ring. These accomplishments demonstrate that CEMILAC is a forerunner in the certification of AM parts.

To advance to the certification of rotating critical parts, CEMILAC has taken initiatives to form a national committee to formulate certification criteria and, seminar/symposium are taken up recently.

Aditya Chandavarkar: What is the expectation from CEMILAC and the Indian Defence from the Additive Manufacturing stakeholders from India?

Shri APVS Prasad: As AM is a very cost effective methodology for replacing an existing component with an indigenous component, CEMILAC wants industries to get their powders, machines, and components certified as soon as possible. Users have a list of components that they want to make using Additive Manufacturing technology as this technology meets their needs. Essentially Users have three requirements: (1) a quick turnaround time, (2) able to complete the component with minimal cost and documentation, (3) meet the low order quantity.

ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

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Creating waves in the world of Additive Manufacturing and 3D printing is the 6th edition of the AMTech Expo 2022, India's only dedicated additive manufacturing tradeshow to be held at the Hitex Exhibition Grounds in Hyderabad, India, from December 2nd to 3rd, 2022.

AMTECH 2022 is supported by the National Centre for Additive Manufacturing (established by the Ministry of electronics and information technology, Govt. of India and ITE&C Department, Govt. of Telangana), CEMILAC (a laboratory of the Indian Defence Research and Development Organisation, The Raja Ramana Centre for Advanced Technology (unit of Department of Atomic Energy, Government of India) and other local and global industry bodies.

AMTech is India's largest business networking platform for Additive Manufacturing Technology, where you can experience the entire ecosystem of 3D Printing and Additive Manufacturing. Projecting a remarkable 50% increase from the previous edition, the AMTech Expo 2022 will see 150+ brands showcasing their products and services across the Additive Manufacturing supply-chain. The AMTech Expo 2022 will have cutting-edge exhibits, offer learning opportunities from expert-led conferences, provide networking platform with the industry stalwarts, so as to be able to make an informed choice on where additive manufacturing fits into one's production process. AMTech will provide a comprehensive overview of the entire value-chain of Additive Manufacturing including core technologies and allied pre and post processes.

Some of the key highlights at the AMTech Expo 2022 will be live Machine Demos, product launches, an expert led technical conference, a 3D printing Start-up Challenge powered and focussed zones for Healthcare and Construction 3D Printing. Academia and Research labs across the country will also showcase their expertise. In attendance as trade visitors will be professionals from a wide range of industries such as Tooling, Automotive, Aerospace, Government, Defence, Healthcare, Construction, Dental, Medical Devices, Education and much more.

Speaking about the Expo 2022, Mr. Aditya Chandavarkar, (Co-Founder, AMTECH Expo) shared, "The Additive Manufacturing and 3D printing ecosystem is fast-changing in India, as much as the rest of the world. The 3D printing scenario for the future is very promising as it will provide much bigger, faster and cost-effective options for a variety of industrial applications. The rising demand for additive manufacturing to fulfil end parts will continue to drive improvements in the industry. Many businesses will benefit from a focussed business networking and knowledge platform for Additive Manufacturing with the AMTech Expo 2022."

Adding to this, Mr. Dilip Raghavan (Co-Founder, AMTECH Expo) shares, "Exhibitors at the AMTech Expo 2022, will cover areas such as Design and Product Development, Pre-Processing, Additive Manufacturing Services, Software, Materials, Additive Manufacturing Technology, Research and Development, 3D Scanning and Metrology, Post-Treatment, and Lab Equipment and Testing. AMTECH Expo 2022 is the place to be, for anyone seeking solutions in Additive Manufacturing."

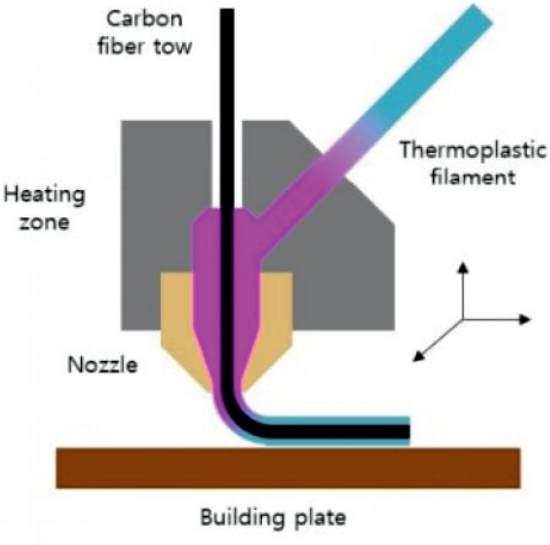
So, if you wish to register for the Expo 2022 or know someone who would be able to benefit from Additive Manufacturing in their production process, AMTech Expo 2022 is the gateway to the world of Additive Manufacturing and 3D Printing!

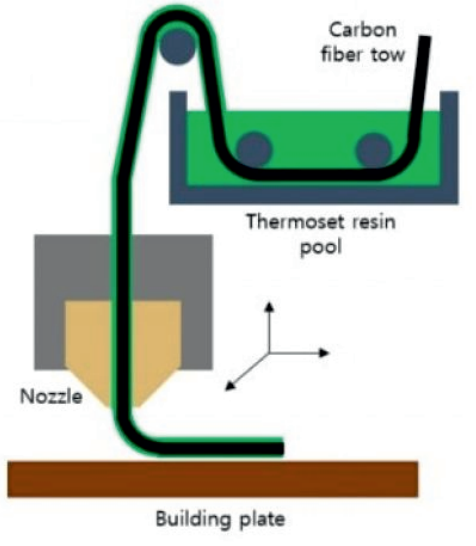
For more details, contact: marketing@catnewtech.com or visit www.amtechexpo.in

Reinforced Polymer Composites based 3D Printing: a revolution within additive manufacturing

Rajkumar Waghmare

The use of composite additive manufacturing has been increasing in industry. The article discusses reinforced polymer-based 3D printing and two cornerstone automated processes.





Reinforced Polymer Composites based 3D Printing is currently utilised in aerospace and defence industry and is growing domain. Additionally, new technology and machines being developed is transforming its potential in industrial applications

The use of Reinforced Polymer Composites materials has been increasing rapidly over the last few decades due to their high strength and stiffness to weight ratio, which is difficult to achieve using conventional materials. Composite manufacturing can be tailored for complex geometries without any compromise in their mechanical properties. Composite materials in broader perception are composed of two or more different phases like a matrix phase (usually metal, ceramic or polymer) and a reinforcement phase (particulates, continuous or discontinuous fibers, etc.) Among these, fiber-reinforced polymer (FRP) composites offer some

distinct advantages over other composite systems. These composites possess considerably higher specific strength and modulus properties, are lighter in weight, and offer more flexibility in designing large structures and finished products than other composite counterparts. FRP composite products are conventionally manufactured using established processes like hand layup, vacuum-assisted resin transfer molding (VARTM), resin film infusion (RFI), or autoclave pre-preg processes.

However, traditional composite manufacturing processes are time-consuming and are heavily dependent on skilled manpower. The scope of human error is always a major concern during these 'irreversible' manufacturing processes, which can lead to derailment of the fabrication process or serious manufacturing flaws in the product. The industry has so far managed to overcome the limitations of human error by using automation in fiber layup processes for additive manufacturing of composites.

PLA and a polyurethane-type filaments as the thermoplastic matrices and an epoxy as the thermoset matrix widely practicing in industries. The PLA filament and CF was smoothly extruded from a nozzle for thermoplastic composites and lot of literature available on thermoplastic additive manufacturing of composites. For thermoset composites widely following automatic tow placement methods for composite manufacturing.

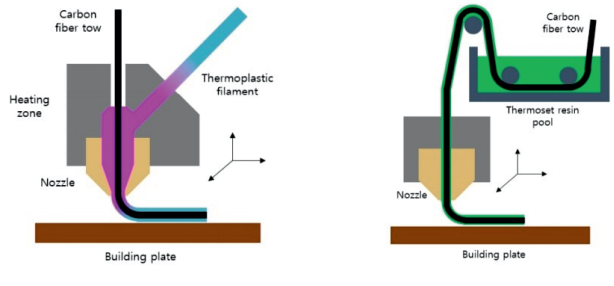


Figure 1. 3D printing system of continuous carbon fiber-reinforced polymer composites for (a) thermoplastics and (b) thermosets.

It became clear that the manufacturing process was extensive, and automation would be advantageous. Two of the cornerstone automated processes to appear were automated tape laying (ATL) and automated fiber placement (AFP) as shown in figure 2.

1. Automated Fiber Placement (AFP)

The AFP process consists of a gantry/robotic system with an attached fiber placement head. The AFP head enables multiple strips of composite material, or tows, to be laid onto a tool surface. Adhesion between the incoming tows and substrate is ensured by using appropriate process conditions such as heating, compaction, and tensioning systems. A series of tows forms a course, courses are then combined to create a ply, and multiple plies create a laminate

Thermoset prepregs utilize a combination of fibers and thermoset resins. Thermoset resins are polymer resins with a relatively low viscosity, and when cured form a rigid 3D lattice structure

These materials are the most common AFP material used because they are the easiest to manufacture due to the comparatively low ideal processing temperature required for successful layup. Since the processing temperature required to reach the gel or melt point of the material is close to room temperature, less heat is necessary leading to easier manufacturing. In addition, thermoset tapes require a secondary processing step,

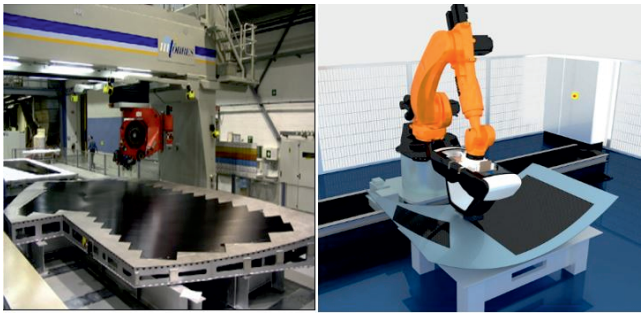


Figure 2: ATL/AFP head (a)gantry type
(b) robot with AFP Head laying onto a female tool

such as autoclave consolidation, increasing processing time and cost. Typically, thermoset processing temperatures should not exceed ≈70⊠C in order to prevent initiation of the cure reaction within the resin. Further, due to the thermoset resin within the material, it is required to keep the material frozen to slow the curing reaction.

2. Automated Tape Laying (ATL)

Tape laying head operate without any difficulties for carbon/epoxy tape at speeds up to 100 m/min while achieving aerospace grade placement accuracies on complex contours. It applies 75 to 300 mm carbon/epoxy tape with any orientation and number of plies, ensuring consistent quality, part shape, thickness and strength. The head allows fast, simple side loading of tape rolls up to 300 mm wide and 650 mm diameter. AFP systems differ from ATL in the width of the material that is laid down with typical material widths of 3.2 mm, 6.4 mm, and 12.7 mm, however AFP will normally deliver several tows in a single sequence, termed bands. A band then forms a course, while a sequence of courses is termed ply. Presently, AFP can deliver up to 32 tows in parallel at linear speeds of up to 1 ms-1.

AFP productivity is typically lower than ATL because it is generally employed for more complex parts. For example, productivity for layup of a complex fuselage section is 8.6 kg/h, which is about half of current ATL rates. During AFP layup tow tension on the head is negligible or controlled to be very low to enable layup into the convex geometries and features.

AFP systems tend to use flexible rollers to compress the material to get reduce voids formation between two layers as well as final cured composite part, but as previously mentioned for ATL the short contact times may be ineffective to achieve sufficient compaction. To heat the tape shot torches, Laser, and infrared irradiation techniques are used. Robotic systems improve the affordability of AFP since industrial robots are significantly cheaper than gantry units, and as force during layup of the tapes result robotic AFP systems are presently cheaper than comparable gantry AFP or ATL systems.

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  com
- CAESA Automated Fiber Placement (AFP) and Automated Tape Laying (ATL) technologies.

ABOUT THE AUTHOR

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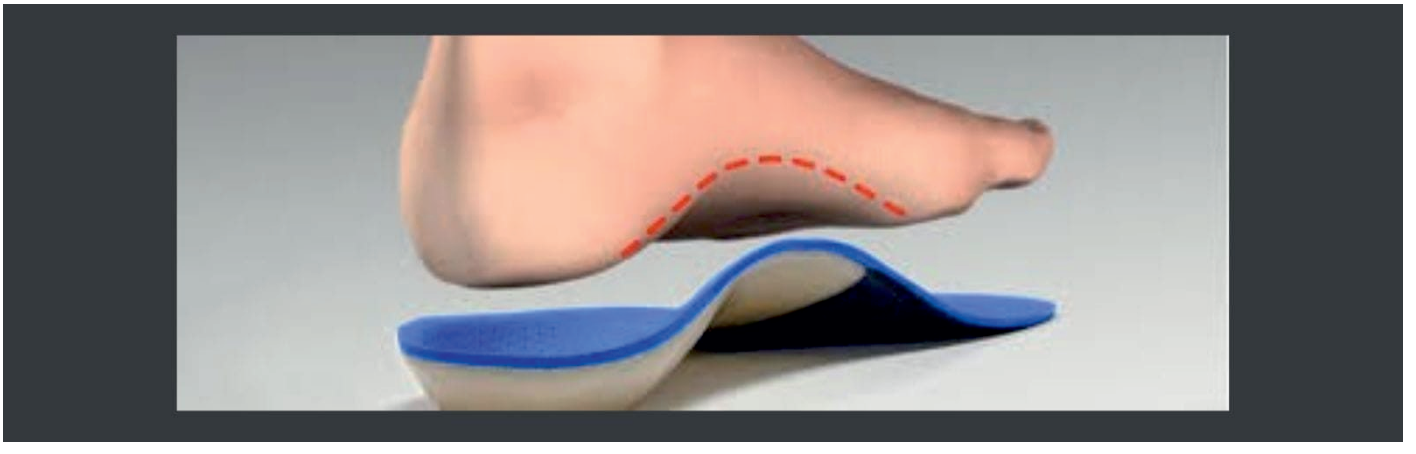
Rajkumar Wagmare has been involved in the field of polymer composites for more than five years. He is currently Research Fellow/PhD Scholar in Composites Research Centre of Research and Development Establishment (Engineers), DRDO, Pune. He graduated in Mechanical Engineering from the BVBCET Hubli, did his M. Tech in Manufacturing Science and Technology from RIT Bengaluru and pursuing his PhD from Defence Institute of Advanced and Technology Pune.

His areas of interest are Additive manufacturing of metals and thermoplastic and thermoset polymers, continuous carbon fiber, nanofiller, Laminated Composites materials, material characterization, Materials Testing, material processing, metal casting, welding, microstructure of metals and polymers. Repair of composites, bonding of metal and composites, honeycomb structures, SEM Analysis, XRD Analysis, Finite Element Analysis, Structural Health Monitoring, NDT, Rajkumar has 3 international journal publications to his credit.

Digitizing the O&P Practice – 3D printed custom Insoles

Manoj Pillai & Garima Chawla

Orthotics and Prosthetics market in UAE is mature with highly qualified professionals working very closely with Orthopedic doctors and hospitals.



This first part of Digitizing the O&P Practice article on 3D printed custom insoles summarizes the benefits of the same and how Falcon Technologies have adopted the technology.

A perfectly fitting footwear is like a perfectly aligned wheel for a car. With the correct footwear, the comfort level increases multifold, keeps the body in correct posture, reduces the pressure points in the feet, balances the weight of the body equally. For people who has a feet problem, either a flat foot or diabetes related complication, the normal shoes won't work and will need a customized solution. The most affordable one is a custom insole manufactured as per the requirement of the patient which can be used in all the shoes that the person wears. When it comes to mass customization, 3D printing is the solution. This article summarizes the benefits of customized insoles and how Falcon Technologies have adopted that using HP MJF Technology. Read further to know more.

A removable shoe insert, also known as foot orthosis or insole can solve several problems, including the following: daily wear comfort, treatment for Planter Fasciitis, supporting the arch relief from arthritis, low back ache, knee pain, leg length discrepancy etc.

Globally the insole market is around US$ 34.4 billion.

The global insoles market is projected to garner momentum at a compound annual growth rate of more than 7% over the next 10 years. By 2031-end, the market is anticipated to exceed US$ 70 Bn. (Source)

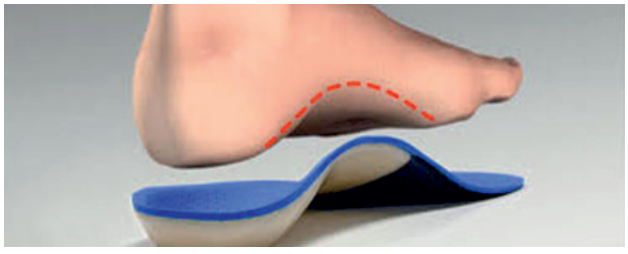


Figure-1-Custom-Insole

According to the research, 3D printed customized insoles are gaining high popularity. These insoles are manufactured in less time and are highly ergonomic in nature.

Over the counter partially custom insoles are available very easily at drug stores in small, medium & large sizes.However,the "one size fit all" policy doesn't work for patients with a clinical problem. Patients would have different issues, anatomy and lifestyle pattens. Therefore, the best insole that can provide you comfort would be a customized one and 3D printing offers the best solution when it comes to mass customization.

Benefits of 3D Printed and Customized Insoles

- Precise fit – The custom insoles are made based on your unique health history and the type of shoes you prefer to wear.
- Relief from pain – Providing support and cushion which act as shock absorber when you walk, helps preventing excessive load on your joints
- Injury prevention- Extra support for your feet and ankles significantly reduces your risk of further foot or ankle injuries, including fractures and sprains. Your custom insoles provide a stable surface that completely supports your foot and leg motions.

Whom to consultfor the foot assessment?

A podiatrist should be consulted who will check your

Figure 2: Traditional Custom Insole Fabrication

condition and will recommend the appropriate treatment plan, a badly designed insole can affect the entire body and can cause issues including back pain.The podiatrist will take the measurements give the prescription and may refer you to an orthotics and prosthetic clinic who will make the customized insole for you. The podiatrist or the clinician will make the measurement which could be using a foam box or using a plaster cast or using digital scanners which we as a 3D printing service bureau will advise.

Traditional methods of making in insole is by making the mold either from a foam box impression or from the cast.

Converting to Digital Workflow using 3D scanning

Conventional methods of making an insole requires the

Figure 3: IPad with Structure Sensor used for scanning

data is collected using a foam box or a plaster scan. This is very cumbersome, additionally if the foam box or the cast needs to be sent to a fabrication unit, it causes additional time and effort. The plaster can get damaged in transit and disturb the data and if it takes a lot of space to store the casts. Falcon Technologies International is supporting the clinicians and O&P practitioners to convert the process into a digital workflow. In the modern practicewe can use a digital a scanner and save ample amount of time and provide much accurate results. These scans are made by having the patient place the foot on a flat surface with line of sight available for the digital scanner. A very simple solution is use an ipad and structured scanner.

Once the data is acquired, the clinician and design the insole or the data can be digitally transferred to Falcon Technologies with the prescription, and we will complete the design and print the shell. The process of

Figure 4: Digital scanner used for Custom Insole measurement

design and delivery completes within in less than 3 days. More about the design and conversion of the digital workflow will be detailed in the follow-up article. You may contact us on fti.3D@falconrak.ae or manoj.pillai@falconrak.ae or Garima.chawla@falconrak.ae for more detials.

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Manoj Pillai

AVP Commercial, Additive Manufacturing at Falcon Technologies International LLC

Leading the AM division of Falcon Technologies International. Looking for growth through industrial applications in polymer and metal AM through, scaling locally, international collaborations and inorganic growth.

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Garima Chawla

BD manager, AM; Falcon Technologies International; Ras Al-Khaimah

Garima Chawal is currently working as BD manager with Falcon Technologies International LLC. She Graduated in the year 2009 and worked at St. Stephen hospital in a variety of settings include stroke rehab, Intensive care unit, orthopaedic care, gynea, post surgical rehabilitation. She also has Post grad in Clinical Research, worked with the world renowned Indian Institute of Technology (IIT Delhi) as a project associate.

Additive Manufacturing of Flexible Component Retention Systems

3D Systems

Manufacturing complex flexible retention systems using additive manufacturing for automobile sector

Channels incorporated for zip-ties in order to ensure performance and guide assembly

For decades, photopolymer additive manufacturing (AM) has been leveraged to accelerate the development of innovative automotive components and systems. However, these parts were largely used for non-functional form and fit evaluations, or as patterns to create parts using a traditional molding or casting approach. This narrow use of the technology was primarily due to former limitations in productivity, material properties over time, or both. Now, 3D Systems is significantly expanding the value proposition of AM

through new material development, transforming the technology into an innovative manufacturing method for parts that not only meet performance requirements for automotive conditions, but do so over significantly longer duty cycles. In this application brief you will learn how these materials and technologies can be used in developing and producing complex flexible retention systems in vehicles.

The modern vehicle offers many different propulsion systems working in concert with cooling, climate, infotainment, driver information, security systems, and more. All of these require various electrical, energy, and fluid transfers throughout the chassis, body, and interior. These transfers involve routing through limited packaging spaces and challenging operational environments. In many cases the design of these retention or routing components is dependent on features that are produced in smaller volumes due to vehicle customization. Small lot sizes make traditional tooling costs prohibitive. These constraints have posed a seemingly impossible challenge for engineers trying to deliver robust design solutions in time for product launch — until now.

Examples of AM Retention Solutions

Retention devices are found throughout a vehicle, and service the movement of electrical/EDS energy, coolant fluids, washer fluids, pneumatic and vacuum energy, etc. In addition to routing energy and fluids through the system, they often also integrate components like power distribution elements (i.e. relays, fuses, solid state devices, etc.). You will find examples of these types of components throughout this brief.

Key Drivers of AM for Flexible and Fluid Retention Systems

Part consolidation and improved package allocation

Additive manufacturing allows for greater design freedom to incorporate multiple components and features into a single part. Packaging space is often a premium for these types of components, so utilizing and conforming to complex environments is critical. This application not only improves assembly efficiency and part quality, but also increases packaging efficiency.

Materials suitable for functional lifecycle

Photopolymer materials that are suitable for functional applications over many years of automotive duty cycles are required. 3D Systems offers a range of materials tailored to specific applications with respect to mechanical properties, surface quality, and environmental robustness.

Flexible production for rapid iteration

Photopolymer additive manufacturing solutions provide the productivity, quality, and fidelity to meet automotive needs. This includes both functional performance as well as aesthetic quality to meet design intent.

Low volume – high value part economics

Additive manufacturing allows for production of tailored designs to meet complex packaging and functional challenges. Elimination of traditional tooling costs and lead time means more iteration, faster time-to-market, and optimized design cost for lower volumes.

Advantages of Using AM

- Design freedom to consolidate features into a single component
- Design freedom to maximize package efficiency
- Accurate, repeatable production of complex designs for optimized performance
- Efficient production and post-processing improve manufacturing output
- Tool-less production enables lower volume, high value components in vehicles

Workflow Solution & Best Practices

Example Part: Harness Retention Component
Technology: Figure 4
Printer: Figure 4® Modular
Material: Figure 4® Rigid 140C Black
Functionality: The harness retention component is responsible for directing and holding harness bundles through a complex route or path in the vehicle. This is often due to very limited packaging space, a challenging environment, complexity of multiple take-outs, etc. The retention device includes complex design features such as push pins, zip ties, tape channels, and the like. In some components, closes, caps, or covers are incorporated to fully cover the routed harness.

Post-Processing: ProCure 750 UV Finisher, part washing equipment, part finishing equipment and tools (i.e. for support removal)

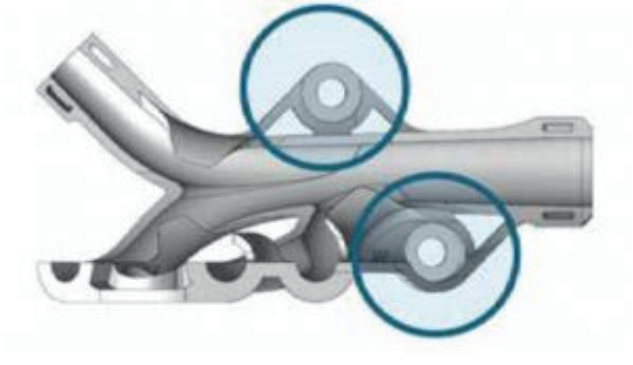
1. Design for Additive Tips

Considerations when designing for additive manufacturing (DfAM) are sometimes dependent on your specific application and the features that you want to incorporate. However, many guidelines are broadly applicable, regardless of how your retention system will specifically be used. As indicated, the process can be improved considerably with regards to efficiency and quality if DfAM principles are guiding your decisions from the start.

Consolidating parts and features

Fluid Junctions: Fluid channels and retention can be incorporated directly into retention systems using AM to eliminate separate T components and additional retention. This means that take-outs for these can be optimized beyond traditional 90-/30-/45-/60-degree angles.

Integrated Stand-Offs: Some components require stand-offs or legs to effectively position and assemble the system in place. With additive manufacturing, these stand-offs can be optimized for the package by eliminating the restrictions on draw direction and draft angles that are typically found in molded designs and leveraging optimal wall thickness for structural performance.



Stand-off design optimized for easy assembly independent of draft angles and wall thicknesses.

Incorporated EDS Components: Solid-state or traditional EDS components can be designed into the component with optimized package and orientation, unconstrained by traditional molding restrictions of draw direction and draft angles.

QR Codes: Incorporate custom QR codes into the part design to track part and/or production lot information.

Custom QR codes and other tracking features can be directly incorporated into the part design without generating any additional process steps.

Incorporating additional retention features

Standard Push Pin/J-Clip Features: Using standard retention components often allows for improved in-field serviceability. Designs for additive manufacturing can easily incorporate standard holes and features for securing these components in place upon assembly and service. The initial assembly can incorporate some of these features to consolidate components for release and assembly while allowing service to remove and replace them with off-the-shelf components as needed. For instance, printing the push pins in position in design while allowing them to be easily removed and replaced in the field through sacrificial features.

Zip-Tie Channels: Sometimes zip-ties may be incorporated as a secondary or service-oriented feature to secure components together. Specific channels can easily be incorporated to ensure performance and guide assembly or service in placing these, especially if retained components have sensitive features to protect.

Channels incorporated for zip-ties in order to ensure performance and guide assembly

Tape Channels: Tape is sometimes used as a secondary or service-oriented feature to secure components together. Specific channels can easily be incorporated to ensure performance and guide placement in assembly and service.

Trough Design: Leverage additive manufacturing and design freedom to more efficiently conform to and leverage available space in sheet metal troughs. Because the cross-section of these is often limited, space utilization is critical.

Assembly Aids: With the design freedom of additive manufacturing, engineers can incorporate assembly features and poke-yokes without the constraints of traditional manufacturing methods. This makes routing, assembly, and service more reliable and of higher quality.

Assembly features can be directly incorporated into the component design.

Integrated Covers

Frequently, the system holding the harness or flexible components will need to incorporate a cover in order to fully secure the harness, tube, or cable in place. In these cases, integrated covers can be leveraged that include

both "living hinges" and more traditional hinge-pin designs. Even in the case of traditional hinge-pin designs, AM production approaches can reduce or eliminate assembly operations. "Living hinges" are likely to be designed to be flexible enough to easily close and secure through snap fits. Once assembled, the snap fits will be the primary mechanism to hold the cover securely in place.

2. File Preparation

*.stl File Resolution: When exporting the *.stl file from the CAD package, consider the balance between resolution and file size. Fine features should be of high enough resolution to guarantee functional requirements, and low enough to ensure an efficient data workflow and file preparation. As a general guideline, we suggest 0.01 mm chord height.

Part Orientation and Design for AM: To ensure optimal surface quality, part orientation must be taken into account. Whenever possible, engineering and design should consider and include build/support features and orientation in the native design process. This will significantly speed up the process for build preparation from the start. For example: point major features in the same direction where possible so they can be self-supporting, which eliminates the need for additional support features. Stacking and integrating support pads into the design from the start will also significantly reduce build preparation and post-processing time, thus increasing the efficiency and quality of the produced part. In addition, adding fillets in certain areas may eliminate or reduce the need for support structures while also reducing stress concentrations.

Software Features to Optimize Designs: Leverage the advanced part stacking features of 3D Sprint for more productive manufacturing. These solutions can also provide texturing for production-level surfaces.

Generate and Add QR Codes: Design teams can leverage their QR-code management solutions or generate QR codes using a free app to create the desired *.jpeg. This can be positioned and wrapped on the part surface to incorporate the QR features in 3D on the surface. A QR code can also be integrated as part of the assembly stack to identify the lot and even scan the code from outside the equipment during the build.

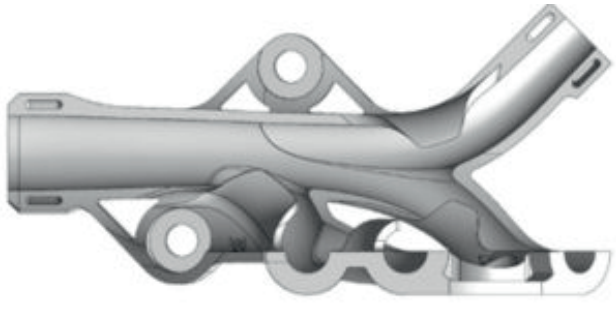
3. Printing Set Up & Parameters

3D Sprint® software is an advanced, single-interface software for intuitive file preparation, editing, printing, and management, and contains fully developed and validated print parameters for all 3D Systems materials. While all parameters are customizable, we recommend our default parameters. For advice on customized parameters, contact the experts in our Application Innovation Group.

Feature Specifications

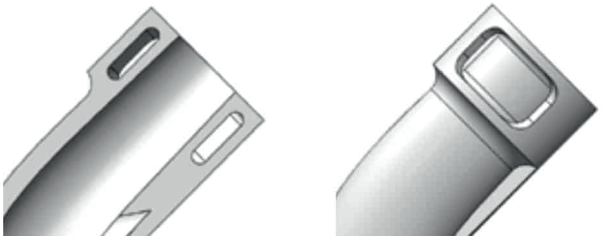
Achievable minimum feature sizes are highly dependent on the combination of additive manufacturing technology, specific material, design, and print orientation. For a clear assessment of the feasibility of a specific component, please reach out to the 3D Systems' Application Innovation Group.

This harness retention component was produced with Figure 4® printing technology and Figure 4® Rigid 140C Black material. Wall thickness was designed with 2 mm, going down to 0.8 mm at the thinnest sections.

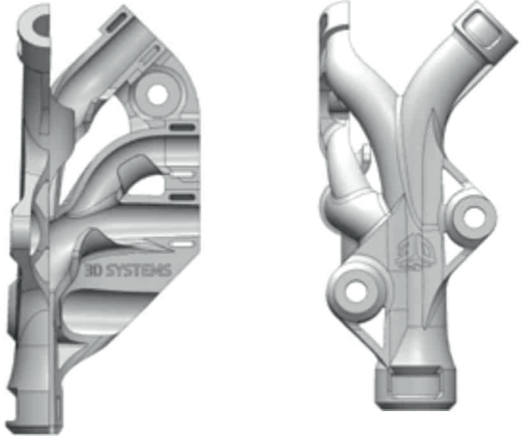


Holes and channels: Achievable minimum hole diameters are dependent on the aspect ratio of diameter and depth/ length. For example, a 0.5 mm diameter hole that is 5 mm long, may be easier to realize than a 0.5 mm hole that is 20 mm long.

When incorporating features such as blind holes and channels, it can be preferable to include a vent to allow for optimal draining and faster, more effective post-processing.



Open zip-tie channel to allow for faster and more efficient post-processing.



Fonts of this logo print are 3mm high and 0.3mm debossed.

Wall thickness: Wall thickness is a function of the design requirements of the component, but the system can achieve detail down to less than 0.5 mm.

4. Post-Processing

The steps for preparing flexible component retention vary from user to user, but the basic steps include:

Step1: Washing parts to remove excess material (on the platform, if possible); make sure there are allowances for the stacks to let cleaning solutions flow through effectively

Step 2: UV post-curing (on the platform, if possible)

Step3: Removing parts from the platform and removing supports

Step 4: Detail cleaning, as required

5. Solution Components

MATERIALS

Accura® AMX™ Rigid Black (SLA): Production-grade stereolithography resin featuring long-term environmental stability for large-scale plastic parts with demanding mechanical performance requirements and exceptional surface finish.

Figure 4® TOUGH-BLK 20 (Figure 4): A strong material with industry-leading environmental stability. Parts feature an exceptional surface finish, high precision, durability, and long-term stability for fast, high-performance prototyping and production.

Figure 4® Rigid 140C Black (Figure 4): A rigid heatresistant material combining high strength and hig Figure 4® High Temp 150C FR Black (Figure 4): UL94 V0 rated flame-retardant black plastic with >150˚C heat deflection temperature.

Figure 4® FLEX-BLK 10 (Figure 4): A flexible material for the production of exceptionally durable polypropylene-like parts for a wide variety of prototyping, functional testing, and low volume production applications.

Figure 4® Tough 65C Black (Figure 4): Black plastic for long-term use parts with a good combination of impact strength, elongation, and tensile strength.

DuraForm® EX BLK (SLS): Tough, oil- and fatigueresistant nylon 11-based plastic engineered for additive manufacturing to withstand repeated abuse in harsh, frequent-use environments.

PRINTERS

ProX® 800 (SLA) – SLA quality at high throughput to

address the broadest range of applications.

Figure 4® Standalone and Figure 4® Modular: Figure 4 Standalone delivers ultra-fast and affordable 3D printing for same day prototyping and low-volume production. Figure 4 Modular is a scalable, semi-automated 3D manufacturing solution designed to scale with growth. It has auto-refill capability and additional Z-axis height for more production stacking.

ProX® SLS 6100 (SLS): Production-grade nylon 3D printer delivering best-in-class part quality, fast build times, and automated production tools.

sPro 140 and sPro 230 (SLS): Medium and large capacity SLS printers for high throughput of tough and durable thermoplastic parts.

SOFTWARE

3D Sprint® Software: Advanced, single-interface software for intuitive file preparation, editing, printing, and management. 3D Sprint is included with 3D Systems' plastic 3D printers.

Geomagic® Freeform® Software: The industry's most comprehensive, organic, hybrid design software for complex surfacing and texturing.

POST-PROCESSING

ProCure 750 UV Finisher: Achieves final curing of SLA parts through uniform exposure to UV light during a specific period of time.

LC-3DPrint Box: Post-cures Figure 4 parts to obtain final material properties through quick and uniform exposure to UV light.

6. Critical Success Factors

The right AM solution is only part of the equation for success. How AM is onboarded, integrated, and implemented all contribute to its impact.

Onboarding – training a technology champion

Having at least one trained, in-house AM expert goes a long way in a company's successful adoption of AM. 3D Systems offers a variety of trainings through our Application Innovation Group to bring your technology champion up to speed to help your company get a running start. 3D Systems customizes training content to your specific needs and guides you in how to use AM to maximize the effectiveness of your retention component applications.

Integration – training on end-to-end processes for optimizing effectiveness of am

3D Systems partners with you throughout the entire AM process, from file set-up to finished part. As part of equipment installation, 3D Systems provides essential knowledge on operating the system, as well as tips and tricks to get the most out of your AM applications.

A strong partnership helps deliver a smooth and effective AM experience, both when working with 3D Systems and interdepartmentally. To maximize the productivity and output of your system, regular communication between the designer, AM expert, and post-processing experts is essential.

Implementation – realizing the advantages of am

AM delivers tangible impacts to your bottom line for flexible component retention devices by delivering quicker design iterations and optimized manufacturing performance and productivity compared to traditional molded components. Advancements in photopolymer materials by 3D Systems have transformed the long-term stability and performance of parts designed for automotive use.

Traditional Manufacturing

- Design constrained with draw and draft angles
- Long-lead and expensive prototype tooling
- Long-lead and expensive production tooling

- Materials designed to perform during long-term use
- Low piece price suited for higher volume / mass production components

3D Systems

- Significantly increased design degrees of freedom for part
- consolidation and package efficiency
- Accommodate rapid changes and print parts as needed
- Lean manufacturing – print parts as needed
- Materials designed to perform during long-term use
- Eliminates tooling costs for low-volume part economics

Why 3D Systems

When it comes to choosing an additive manufacturing solution for flexible component retention in automotive, you want to ensure that your systems are packaged efficiently, ensure performance, and deliver with quality throughout the duration of the automotive lifecycle. 3D Systems has developed innovative materials that perform over time, along with an equipment and solutions portfolio that is proven in the automotive industry.

Working closely with all the automotive industry leaders has led to 3D Systems' development of a complete solution package comprised of integrated hardware, software, and materials, as well as expert application knowledge, including onsite field service. Unlike other 3D printer providers, 3D Systems' complete solution for developing complex automotive components is the result of constant collaboration with the industry across many applications.

Our hardware has been developed to work with the most advanced photopolymer (SLA) and selective laser sintering (SLS) materials, assuring the performance of our printed parts for automotive use. Our software allows you to quickly modify and set up print files for rapid and accurate printing with accelerated post-processing that enables curing and finishing of parts in hours. Our flexible yet rigid materials deliver high performance in complex environments, providing vehicle programs with the confidence to deliver the most advanced vehicles to meet their customers' needs over the full span of ownership. Our expertise delivers an excellent AM experience by meeting and exceeding the demands of the key applications you are utilizing to drive your brand, with broad field service coverage to support your nonstop innovation.

ABOUT THE AUTHOR

3D Systems

More than 30 years ago, 3D Systems brought the innovation of 3D printing to the manufacturing industry. Today, as the leading additive manufacturing solutions partner, we bring innovation, performance, and reliability to every interaction - empowering our customers to create products and business models never before possible. Thanks to our unique offering of hardware, software, materials, and services, each application-specific solution is powered by the expertise of our application engineers who collaborate with customers to transform how they deliver their products and services. 3D Systems' solutions address a variety of advanced applications in healthcare and industrial markets such as medical and dental, aerospace & defense, automotive, and durable goods. Learn more at www.3dsystems.com.

Opportunities for Additive Manufacturing in Space Applications

Ankit Sahu

Traditional construction is responsible for generating 27% of global CO2. Alternative methods such as 3D printing hold promise

Additive Manufacturing is the technology that is used to build 3D objects by the addition of various layers made up of plastic, other polymers, metals and any other concrete thing. Technology used varies from 3D printing to layer manufacturing to rapid prototyping. Additive Manufacturing has very often been used for various fields such as medicinal implants, automobiles, fashion and other plastic prototypes. Off late, the technology has been moving to even more advanced fields such as space research and creating parts for space.

Additive Manufacturing in space has a very bright future and may be the key to easy human space travel and colonisation in other planets. Most of the parts required in space research are made of plastic or some metal and Additive Manufacturing is the key to a future where all broken parts can be fixed with less labor, money, resource and time. Additive Manufacturing is already playing a huge part in making production costs of satellites low. Apart from that, these 3D figures are also very light and therefore make the weight of the satellites lighter too!

Many articles and reports have suggested that in the near future space ventures could in fact be one of the largest manufacturing sectors, and this all would be credited to Additive Manufacturing and the fact that 3D printers and other technology could work in space in a zero gravity situation. Technology has reached a stage where you can print your own engine in space and if we take this forward, Additive Manufacturing could open up many more aspects in space.

3D Printing on ISS

Long Life Additive Manufacturing Assembly (LLAMA), is a project by NASA to test 3D printing methods for building Liquid Rocket Engine components in order to save a considerable amount of time and money. As it can take many months or maybe even a year to procure and fabricate Liquid rocket engine hardware components by traditional manufacturing processes. With the help of additive manufacturing the production time for rocket engine nozzles can be cut down by more than half compared to traditional processes; AM also reduces the part count as it can combine multiple pieces by part consolidation.

The copper alloy composite nozzles produced by AM when tested under hot-fire were able to withstand much higher temperatures than traditional metallic nozzles, hence AM produced components are more efficient and have greater performance margin.

NASA sends up about 7000 pounds of spare parts to the ISS every year to support spaceflight missions. The ISS has about 29,000 pounds of hardware spares/ replacement units. NASA has set up In-Space manufacturing in the ISS to lighten the load and subsequently reduce the cost.

Additive Manufacturing in SpaceX

SpaceX started using AM to design and manufacture complex metal parts as it would eliminate the entire process of outsourcing the work to other suppliers, thus producing the part in the SpaceX factory itself. This reduces the lead time, costs, allows for stricter quality control and also safeguards intellectual property.

SpaceX was one of the first companies in this sector that introduced Additive Manufacturing as a major part of their production. They have been continuously evaluating the benefits of AM and its techniques required to design and develop flight hardware.

Additive Manufacturing in ISRO

Indian Space Research Organisation (ISRO) have also started using Additive Manufacturing technology to design and produce components that are used in satellites and space crafts.

ABOUT THE AUTHOR

Ankit Sah

Director, Objectify Technologies Private Limited.

He has pursued his Bachelor of Engineering, 2010 in MECHANCAL ENGINEERING from RV College of Engineering, Bangalore and his Master of Science in Manufacturing Technology Engineering, 2012 from Warwick University, UK. He founded Objectify Technologies right after returning from UK in 2013, at SIIC Incubation Centre at IIT Kanpur.

Potential Cooling Solutions using Powder bed fusion additive technology in aircraft interiors.

Shreekanth Rao

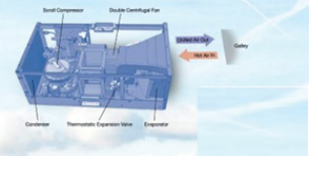
The article elaborates on the role of metal additive manufacturing in making modular, low profile space-efficient systems for aircrafts

Introduction

Aircraft cabins have a very strong need for cooling and especially in galleys, cooling is required to store all the food and beverages. Typically refrigerant based heat exchanger consisting of condenser evaporator compressors is employed to achieve the desired cooling.

Although their performance is acceptable they consume a lot of space, the units are not modular and the use of refrigerants impact on global warming. Cooling requirements in interiors system demand a more modular low profile space efficient systems which can be integrated into multiple applications like galleys, Seats etc.

Typical Refrigerant Based heat exchangers



Discussion on topic

In order to achieve a space efficient modular cooling solution Collins Aerospace has introduced SpaceChiller™, a modular thermoelectric cooling system scalable to fit a variety of applications throughout an aircraft's interior. Introduced at the Aircraft Interiors Exposition in Hamburg, Germany, SpaceChiller quietly and efficiently chills compartments to food-safe temperatures without the use of refrigerants that may impact global warming.
With applications ranging from premium suites and passenger social zones to single galley inserts and whole cart bays, airlines benefit from flexibility in service, storage and space without sacrificing room for passengers and flight attendants.

SpaceChiller uses advanced heat sinks, initially developed for The Defense Advanced Research Project Agency (DARPA), that reduce power consumption up to 50% over alternate thermoelectric systems and can be leveraged across multiple service areas and passenger seats.

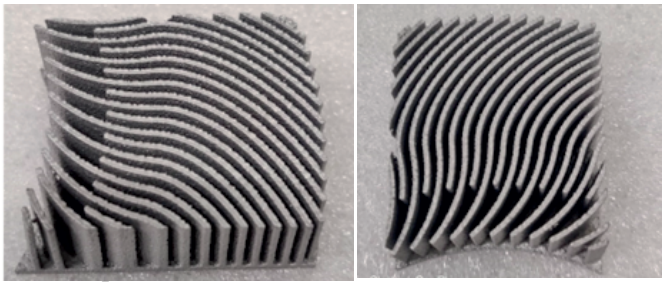
Collins Aerospace's SpaceChiller™ has been named a winner of a Crystal Cabin Award. A jury of 27 aviation industry experts announced the winners across eight categories June 14 in Hamburg, Germany.

Spacechiller images from the Hamburg expo

The important factor governing the over all size of the heat exchanger unit is the fin gap. Minimum fin gap is essential to achieve higher heat transfer performance

per unit size. Typical subtraction techniques results in larger heat exchangers having an overall envelope of over 18" dia as the fin gaps are greater than 3 to 5 mm (typical). However Powder bed fusion based additive technique has the capability to achieve minimum fin gap (.8mm Typ) and there by reducing the overall size of the unit to less than 6" dia (typical).

Fin designs achievable using additive manufacturing



The additive technology can enable compact space efficient cooling units and with the combination of thermoelectrics can eliminate the need of a liquid refrigerant there by reducing the impact on global warming. The modular design approach can be applied to multiple applications including and not limited to Minibar in executive seating, galley food chillers, seat comforters to name a few.

The challenge with the additive technique is it produces fins which has high surface roughness 10 microns (typical). This can impede the airflow however optimizing the process parameters and techniques like abrasive flow finish can yield a better acceptable surface finish.

Another challenge with additive heat exchanger is the quality and process consistency as well as performance. Closer process monitoring using optical and thermal imaging techniques will instill building confidence in the process itself and reducing concerns for part-to-part and machine-to-machine variations.

Conclusion

Thermoelectric based chiller using additive technology has demonstrated ability to minimize space and weight and achieve complex fin profile only possible via AM. Additively built dual sided refrigerant based heat exchangers having internal channels for conformal cooling is currently being developed for extreme cooling requirements initial trials and burst pressure testing has instilled confidence on the refrigerant based additive manufactured heat exchanger however surface finish and cost challenges are being tackled.

In conclusion, Additive Manufacturing has the potential and design freedom to achieve complex designs and provide solutions. Effectively, utilizing AM technology also requires a culture shift. There is a need to train designers and manufacturing engineers to gain deeper understanding that highlights nuances of additive technology, the benefits of the technology, its challenges, and the new design rules.

About the author

ABOUT THE AUTHOR

Sreekanth Rao

Senior Principal Engineer in Mechanical design team at Collins Aerospace. Over 17 years of vast experience in Product design and development, manufacturing, and prototyping.

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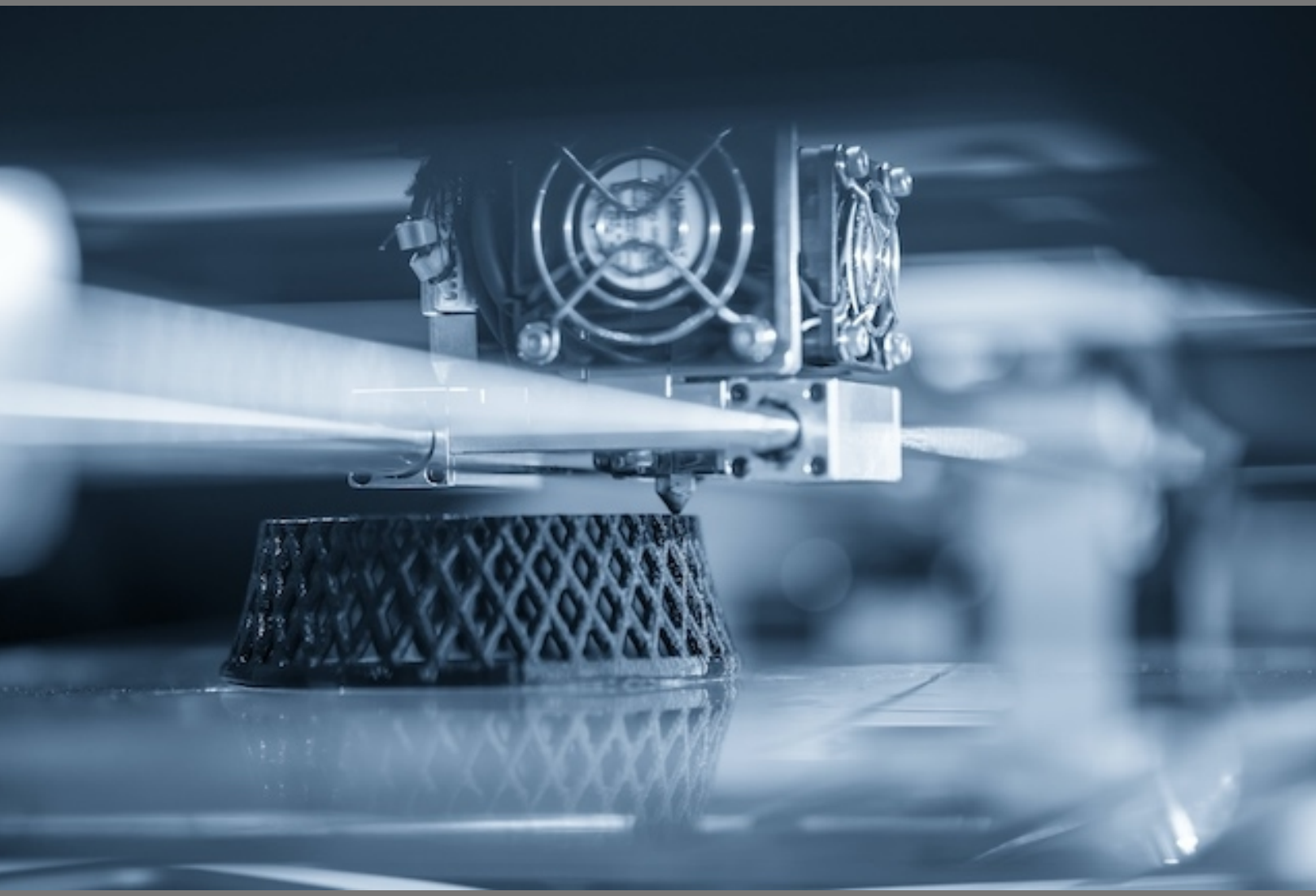


Startups are key for the next wave of disruptive growth for additive manufacturing. AM Chronicle is coming together with AM Ventures, a leading global venture capital firm dedicated to industrial 3D printing for AM Startup Content Series

powered by

AMVENTURES

'Identify' with Complete Efficiency, SelectAM provides solution to identifying parts for Additive Manufacturing

Aditya Chandavarkar and Vaishali Heblekar

In this special Startup Saturday article as part of the AM Chronicle Startup Series powered by AM Ventures we connect with the Founders of Select AM to understand more about their venture

Founded in 2020, SelectAM is a complete software solution to identify parts for additive manufacturing (AM), allowing the user to screen and define business cases from large part inventories to unlock the full potential of AM. The software simulates digital manufacturing workflows with most relevant industrial AM machines and materials available to provide insights on the technical feasibility, the economic potential, and the redesign opportunity of assessed parts.

Founded in 2020, SelectAM is a complete software solution to identify parts for additive manufacturing (AM), allowing the user to screen and define business cases from large part inventories to unlock the full potential of AM. The software simulates digital manufacturing workflows with most relevant industrial AM machines and materials available to provide insights on the technical feasibility, the economic potential, and the redesign opportunity of assessed parts. The user can choose between a top-down (up to 100k parts at once) or a bottom-up (single parts) approach with either the standard or company-specific AM machine and material profiles. The company

recently launched its first commercial cloud-based software 'Identify 1.0' which offers a free-of-charge 1-month trial, and helps 3D nesting for accurate cost calculations.

Brains behind this

SelectAM is the brainchild of co-founders Dr. Niklas Kretzschmar, Lukas Jakob Hafner, Dr. Eero Huotilainen, and Dr. Inigo Flores Ituarte, from Helsinki. Their team comprises of AM experts, experienced software developers, and advisors.

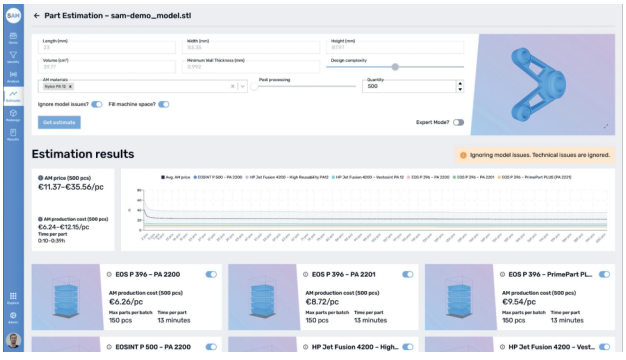
The Before and The After

Today, less than 0.2% of the world-wide manufacturing value is served by additive manufacturing technologies, even though its potential is much larger. Reasons for this situation are multiple, like for e.g., there are knowledge gaps related to AM, the unavailability and inaccessibility of AM in organizations, the poor level of digitization, and overly expensive ways to identify relevant components. Within companies, AM part identification is often performed by engineers in a bottom-up part-per-part approach, uploading CADs and additional part-related information to AM platforms and services. Feedback is retrieved only for the uploaded part(s) regarding the offered AM capabilities of the related contact point in a manual and slow manner. Furthermore, in many cases, CAD data is not even available for numerous parts, which makes it impossible for companies to assess these in respect to the feasibility for AM. To first digitize all parts and then send them to an AM platform is too costly and time-consuming.

Technology

SelectAM conducts this identification approach in an automated, rapid, and user-friendly manner, making it possible for companies to assess their whole digital part portfolio efficiently.

The software is data and process agnostic, considers all



available industrial AM processes, and is more automated than any other solution in the market. The user can start with uploading information only on weight and material of the parts to figure out if a potential AM business case exists. CAD data is not needed in the first assessment steps in the software solution. The software chooses to rather inform the user which parts to digitize to avoid unnecessary CAD file creations. On the other hand, all available data of a part can be harnessed for assessments. Unlike other part identification software solutions, there is no limit to just a few AM processes. The algorithms and technical assessment steps are built in a robust but flexible manner to even ensure the addition of the next AM process innovations to come seamlessly. SelectAM fully automates workflows to provide the first fully automated solution to allow a screening of the whole data library of a large company in less than a workday.

AM Ventures Asks

Along with the Technological innovations, it is important for start-ups to understand how their innovation is addressing the world's biggest Environmental, Social and Governance Challenges. AM Ventures, our co-collaborator for this AM start-up series, poses a question to SelectAM on their contribution to the world's biggest ESG challenges.

AMVENTURES

What do you believe is your company's contribution to addressing the world's biggest Environmental, Social and Governance (ESG) challenges?

SelectAM strives to help the world manufacture viable AM applications faster, smarter, and more ecologically. They know their solution can help manufacture parts more sustainably, since they aim at boosting the adoption of AM in organizations. More parts being produced with AM can mean less waste and a closer manufacture to the end-customer to reduce the shipping of end products.

Funding Facts

- First pilot customer in 2020: testing and validating the solution
- First paying customer in 2021: top-down approach to retrieve price indications rapidly
- In 2022, their office was moved to Maria 01, a leading start-up campus in Northern Europe (Helsinki)
- Official software launch in September 2022 with 10+ companies applying or testing the solution

They seek:

They would like to invite more companies from all around the world to test their solution and provide feedback using the free 1-month trial. They are keen that organizations really try it, join the community, and participate in the tech deep dives. They also look forward to more strategic alliances with software vendors and AM machine manufacturers to create mutual value from real-time data exchange. In addition, industrial AM service providers are also a very interesting stakeholder group where they can work on their network aspect. Going forward, they will be looking to onboard more customers and co-workers once the time comes!

Contact Details
niklas@selectam.io
https://selectam.io

A Quick Recap

- Founded in 2020, SelectAM is a complete software solution to identify parts for additive manufacturing (AM), allowing the user to screen and define business cases from large part inventories to unlock the full potential of AM.

- The software simulates digital manufacturing workflows with most relevant industrial AM machines and materials available to provide insights on the technical feasibility, the economic potential, and the redesign opportunity of assessed parts.

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- Today, less than 0.2% of the world-wide manufacturing value is served by additive manufacturing technologies, even though its potential is much larger.

- Reasons are multiple:
  - Knowledge gaps related to AM,
  - Unavailability and inaccessibility of AM in organizations,
  - Poor level of digitization,
  - Overly expensive ways to identify relevant components.

- Within companies, AM part identification is often performed by engineers in a bottom-up part-per-part approach, uploading CADs and additional part-

related information to AM platforms and services.

- Feedback is retrieved only for the uploaded part(s) regarding the offered AM capabilities of the related contact point in a manual and slow manner. Furthermore, in many cases, CAD data is not even available for numerous parts, which makes it impossible for companies to assess these in respect to the feasibility for AM.

- To first digitize all parts and then send them to an AM platform is too costly and time-consuming.

- SelectAM conducts this identification approach in an automated, rapid, and user-friendly manner, making it possible for companies to assess their whole digital part portfolio efficiently.

- The software is data and process agnostic, considers all available industrial AM processes, and is more automated than any other solution in the market.

- The user can start with uploading information only on weight and material of the parts to figure out if a potential AM business case exists.

- CAD data is not needed in the first assessment steps in the software solution. The software chooses to rather inform the user which parts to digitize to avoid unnecessary CAD file creations.

- On the other hand, all available data of a part can be harnessed for assessments. Unlike other part identification software solutions, there is no limit to just a few AM processes.

- The algorithms and technical assessment steps are built in a robust but flexible manner to even ensure the addition of the next AM process innovations to come seamlessly.

- Fully automates workflows to provide the first fully automated solution to allow a screening of the whole data library of a large company in less than a workday.

- Strives to help the world manufacture viable AM applications faster, smarter, and more ecologically. The solution can help manufacture parts more sustainably, since it is aimed at boosting the adoption of AM in organizations.

- More parts being produced with AM can mean less waste and a closer manufacture to the end-customer to reduce the shipping of end products.
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- Official software launch in September 2022 with 10+ companies applying or testing the solution.

- Inviting more companies from all around the world to test their solution and provide feedback using the free 1-month trial.

- Keen that organizations really try it, join the community, and participate in the tech deep dives.
  Look forward to more strategic alliances with software vendors and AM machine manufacturers to create mutual value from real-time data exchange.

- Industrial AM service providers are also a very interesting stakeholder group where they can work on their network aspect.

- Looking to onboard more customers and co-workers once the time comes!

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ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training and consulting. Among other activities he the Co-Founder of Indian 3D Printing Network and is a subject matter expert on 3D Printing/Additive Manufacturing with good grasp of Additive Manufacturing trends in the Region including India, APAC, Middleeast and Africa.

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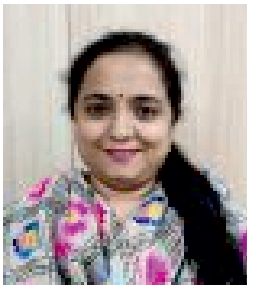


Vaishali Heblekar

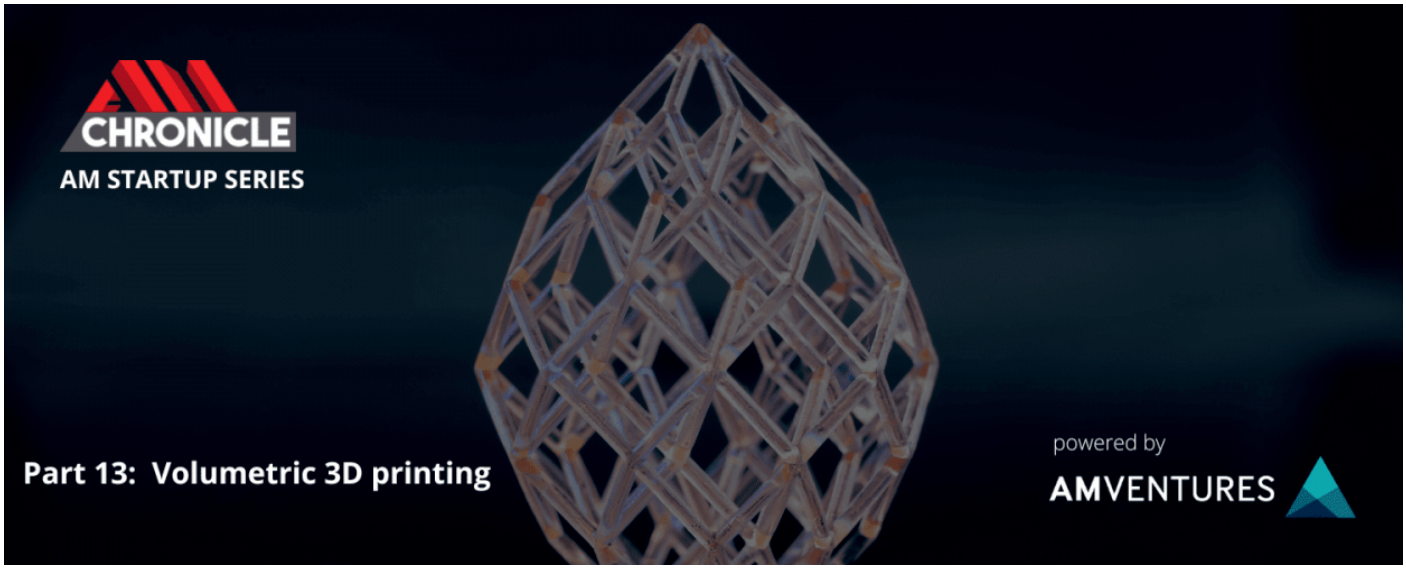
Content Curator at AM Chronicle

An experienced content writer with a strong background in communications and branding. Vaishali also brings with her work experience in Corporate Communications in the manufacturing industry. Skilled in corporate and creative content writing, proof-reading and editing. Also adept at translation from Hindi and/or Marathi to English. Strong communication professional with a masters from Xavier Institute of Communications, Mumbai.

The Xolo effect: Revolutionary volumetric 3D printing to print the unthinkable in seconds

Aditya Chandavarkar and Vaishali Heblekar

In this special Startup Saturday article as part of the AM Chronicle Startup Series powered by AM Ventures we connect with the Founders of Xolo to understand more about their venture



Founded in 2019, Xolo has been pioneering volumetric 3D printing called Xolography. Xolography is fast and can print objects as high as 3 cm in 1 – 3 minutes with a high resolution.

In a Nutshell

Founded in 2019, Xolo has been pioneering volumetric 3D printing. It has invented a proprietary technology called Xolography, which is a revolutionary new method to print any design in seconds.

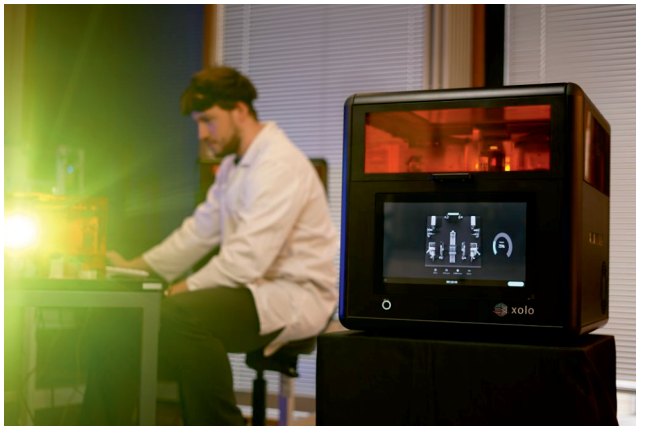
Brains behind this

The brains behind this are Stefan Hecht, a world renown expert in photochemistry, Martin Regehly, a former entrepreneur in the scientific and semiconductor high performance camera space and Dirk Radzinski, a serial deep tech founder.

The Before and The After

In order to address the slow speed of manufacturing, Xolography was chosen to be the solution to address

the three areas of current shortcomings in stereolithography/digital light processing. Xolography is fast and typically prints in between 1 and 3 minutes for 3 cm objects with a high resolution. Xolography produces ultra-smooth surfaces with no staircases up to optical imaging quality. Also, since no support structures are needed, therefore they do not need to be removed. Xolography uses high viscous resins and no additives, which lead to different and superior final material properties.



Technology

Xolography involves volumetric 3D materializing technology based on dual colour photo-initiators. Xolography is a dual-color technology that intersects light beams of various wavelengths to cause local polymerization inside a constrained monomer volume. The xolography process has a resolution that is roughly ten times more than computed axial lithography without feedback optimization and a volume creation rate that is four to five orders of magnitude greater than two-photon photopolymerization when compared to volumetric printing techniques.

AM Ventures Asks

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AMVENTURES

What do you believe is your company's contribution to addressing the world's biggest Environmental, Social and Governance (ESG) challenges?

Xolography is for small centime sized objects down to the nanoscale. Therefore, the material savings do not add up to something which moves the needle in environmental terms. However, Xolography will open up the door for SMEs to innovate in spaces where usually a lot of capital expenditure is required. This, speeds up innovation cycles and will ultimately, benefit everyone.

Funding Facts

Xolo raised a seed round of EUR 2,5 M in 2021. It entered academic markets by selling Xolography printers called Xube in late 2021. Printers are sold to innovative research groups in bioprinting, optics 3D printing and material science.

They seek

Xolography is new and different, with potential applications in many areas. They are always on the hunt for entrepreneurs in residence, people who have specific applications in mind which are only thinkable using volumetric printing. They will help those people

to succeed. The same applies for scientists who are spearheading innovation at the intersection of 3D printing and bio, optics and material science.

Contact Details

www.Xolo3d.com

A Quick Recap

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- Xolography produces ultra-smooth surfaces with no staircases up to optical imaging quality.
- Also, since no support structures are needed, therefore they do not need to be removed. Xolography uses high viscous resins and no additives, which lead to different and superior final material properties.
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Bringing the power of data and artificial intelligence to additive manufacturing industry through Handddle

Aditya Chandavarkar and Vaishali Heblekar

In this special Startup Saturday article as part of the AM Chronicle Startup Series powered by AM Ventures we connect with the Founders of Handddle to understand more about their venture

Created in June 2020, Handddle was set up by Thomas Bourgoin, Pierre Marigo and Dylan Taleb. Handddle's mission is to bring the power of data and artificial intelligence to the additive manufacturing industry, to secure, control and certify their production.

In a Nutshell

Created in June 2020, Handddle was set up by Thomas Bourgoin (INSA Toulouse), Pierre Marigo (INSA Toulouse) and Dylan Taleb (Kedge). The company is supported by AM Start-up Series powered by AM Ventures by Unitec, France Additive, Région Nouvelle-Aquitaine, Aquiti Gestion and La French fab, major players in the support of start-ups in Nouvelle Aquitaine (France).

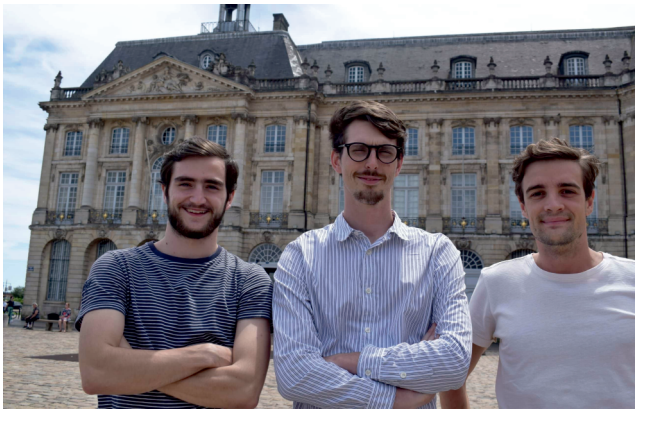
On a mission to solve some of the most important problems of the industry of the future, Handddle assures manufacturers that their 3D printing production processes can manufacture industrial compliance parts. Today, through its expertise, the

start-up supports companies in the analysis of their processes data. Handddle is the central tool around the machines to help understand additive manufacturing on the shop-floor and track every task that takes place during production. This allows manufacturers to improve quality control while guaranteeing productivity anywhere in the world.

A growing company of 11 employees, that consists of software developers, embedded electronics technicians, AI and mechanical engineers, human resources, business and marketing. The expertise used in the research and development of solutions, is always aligned to the objective of providing innovative tools in accordance with the industries with which the company works: Defence, Automotive, or Engineering Schools.

Brains behind this

Handddle has been founded in Bordeaux (France) by Thomas Bourgoin, Pierre Marigo, and Dylan Taleb: 3 software and manufacturing professionals, passionate about technology and innovation.



The Before and The After

As companies qualify and certify Additive Manufacturing processes which will add many more types of parts in the future, there are multiple challenges to be overcome. The more critical a part is, the more important its certification will be. To respond to these challenges, Handddle has firstly imagined SMART FARM, an intelligent and secured 3D printing micro factory which, thanks to its embedded systems, collects and analyses data from production environments. This is a solution adapted to professional machines.

In the growing market of 3D printing, where uses are evolving and additive manufacturing is becoming industrialized, the start-up takes advantage of its technological core, a combination of hardware and software, to adapt it to industrial uses and address industrial production scale with industrial 3D printers. This is how LINE was born, the world's first industrial Internet of Things (IoT) powered by computer vision, machine learning algorithms and real-time data acquisitions. Handddle's mission is to bring the power of data and artificial intelligence to the additive manufacturing industry, to secure, control and certify their production.

Technology

Since the beginning, Handddle desires to offer a unique value proposition on the growing 3D printing market: Lean on data to manufacture certified AM parts. They were the first company to develop 3D printing hubs for manufacturing certified parts, a tool able to create a real smart production line which can secure, control, certify and expand a 3D printing production. The know-how and expertise acquired with SMART FARM permits the engineer team to evolve the solution and to provide a high technology IIoT based on CV and IA. Today, Handddle is the only company on the market to propose a combined solution (Data fusion) of data analysis and new generation tools such as computer

vision and IA, to understand additive manufacturing processes.

AM Ventures Asks

ESG challenges are a part of additive manufacturing by reducing production waste and extending the product life cycle. Handddle permits to relocate industrial production, manufacturing as close as possible to the need. Thanks to their solutions, companies can produce from everywhere in the world and let additive manufacturing (AM) become an industrial production scale. A secure environment for users, thanks to the solutions able to monitor micro-factory and factory data like pollution rejected by the machines. Handddle gives the keys to ensuring the quality of data to assure manufacturers that the AM equipment they use meets health and safety requirements. Access to processes data also allows industrialists to standardize their Additive Manufacturing facilities, for a better flexible supply-chain against the future changes of the industry.
Funding Facts

Founded in June 2020, Handddle bootstrapped initially. It has built a strength in R&D and product development, developing solutions that have been directly delivered to its first industrial partners. Since then, the company has kept growing with 400K€ non-dilutive funding plus turnover without having to deal with any investor interference whatsoever.

- **June 2020:** Incorporation
- **December 2020:** First industrial partner
- **January 2022:** 6 customers widespread in 3 high values industries (Defence, Automotive and Engineering School)
- **September 2022:** New market innovation developed by start-up's own funds

They seek

A growing start-up, they wish to surround themselves with partners who will use their solutions in the future and be part of Handddle's development. After a 6-month R&D phase, Handddle is now looking for industrial partners to demonstrate its new LINE product in a representative environment. The company is growing and so are the teams. Handddle is looking for new talents to accompany them throughout this adventure. They are looking for technical profiles in software and AI development to work on the new product.

Contact Details

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Email: contact@handddle.com
Website: www.handddle.com
LinkedIn: https://www.linkedin.com/company/handddle/

A Quick Recap

- Created in June 2020, Handddle was set up by Thomas Bourgoin, Pierre Marigo and Dylan Taleb. The company is supported by AM Start-up Series powered by AM Ventures by Unitec, France Additive, Région Nouvelle-Aquitaine, Aquiti Gestion and La French fab, major players in the support of start-ups in Nouvelle Aquitaine (France).

- Handddle assures manufacturers that their 3D printing production processes can manufacture industrial compliance parts.

- Through its expertise, the start-up supports companies in the analysis of their processes data. Handddle is the central tool around the machines to help understand additive manufacturing on the shop-floor and track every task that takes place during production. This allows manufacturers to improve quality control while guaranteeing productivity anywhere in the world.

- A growing company of 11 employees, that consists of software developers, embedded electronics technicians, AI and mechanical engineers, human resources, business and marketing.

- The expertise used in the research and development of solutions, is always aligned to the objective of providing innovative tools in accordance with the industries with which the company works: Defence, Automotive, or Engineering Schools.

- As companies qualify and certify Additive Manufacturing processes which will add many more types of parts in the future, there are multiple challenges to be overcome. The more critical a part is, the more important its certification will be.

- To respond to these challenges, Handddle has firstly imagined SMART FARM, an intelligent and secured 3D printing micro factory which, thanks to its embedded systems, collects and analyses data from production environments. This is a solution adapted to professional machines.

- In the growing market of 3D printing, where uses are evolving and additive manufacturing is becoming industrialized, the start-up takes advantage of its technological core, a combination of hardware and software, to adapt it to industrial uses and address industrial production scale with industrial 3D printers. This is how LINE was born, the world's first industrial Internet of Things (IoT) powered by computer vision, machine learning algorithms and real-time data acquisitions.

- Handddle's mission is to bring the power of data and artificial intelligence to the additive manufacturing industry, to secure, control and certify their production.

- Handddle desires to offer a unique value proposition on the growing 3D printing market: Lean on data to manufacture certified AM parts.

- The first company to develop 3D printing hubs for manufacturing certified parts, a tool able to create a real smart production line which can secure, control, certify and expand a 3D printing production. The know-how and expertise acquired with SMART FARM permits the engineer team to evolve the solution and to provide a high technology IIoT based on CV and IA.

- Handddle is the only company on the market to propose a combined solution (Data fusion) of data analysis and new generation tools such as computer vision and IA, to understand additive manufacturing processes.

- ESG challenges are a part of additive manufacturing by reducing production waste and extending the product life cycle. Handddle permits to relocate industrial production, manufacturing as close as possible to the need. Thanks to their solutions, companies can produce from everywhere in the world and let additive manufacturing (AM) become an industrial production scale.

- A secure environment for users, thanks to the solutions able to monitor micro-factory and factory data like pollution rejected by the machines. Handddle gives the keys to ensuring the quality of data to assure manufacturers that the AM equipment they use meets health and safety requirements. Access to processes data also allows industrialists to standardize their Additive Manufacturing facilities, for a better flexible supply-chain against the future changes of the industry.

- Handddle bootstrapped initially and built strength in R&D and product development, by developing solutions that have been directly delivered to its first industrial partners. Since then, the company has kept growing with 400K€ non-dilutive funding plus turnover without having to deal with any investor interference whatsoever.

- Some key milestones are as follows:
  - **June 2020:** Incorporation
  - **December 2020:** First industrial partner
  - **January 2022:** 6 customers widespread in 3 high

values industries (Defence, Automotive and Engineering School)
  - **September 2022:** New market innovation developed by start-up's own funds

- They seek to surround themselves with partners who will use their solutions in the future and be part of Handddle's development.

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- The company is growing and so are the teams. Handddle is looking for new talents to accompany them throughout this adventure. They are looking for technical profiles in software and AI development to work on the new product.

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ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training and consulting. Among other activities he the Co-Founder of Indian 3D Printing Network and is a subject matter expert on 3D Printing/Additive Manufacturing with good grasp of Additive Manufacturing trends in the Region including India, APAC, Middleeast and Africa.

ABOUT THE AUTHOR

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An experienced content writer with a strong background in communications and branding. Vaishali also brings with her work experience in Corporate Communications in the manufacturing industry. Skilled in corporate and creative content writing, proof-reading and editing. Also adept at translation from Hindi and/or Marathi to English. Strong communication professional with a masters from Xavier Institute of Communications, Mumbai.

Simplifying Additive Manufacturing, Paanduv Applications is addressing this with 3D computational modelling

Aditya Chandavarkar and Vaishali Heblekar

In this special Startup Saturday article as part of the AM Chronicle Startup Series powered by AM Ventures we connect with the Founders of Paanduv Applications to understand more about their venture

Founded by Adwaith Gupta in 2020 in Bareilly, Uttar Pradesh, India, Paanduv Applications Private Limited have developed AM PravaH a dedicated world's first all-inclusive 3D computational modelling software for Additive Manufacturing

In a Nutshell

Paanduv Applications Private Limited provides advanced physics-based computational modelling services, advanced software development, and training to companies and institutes in multiple industries. With Additive Manufacturing being one of the main industries of focus, they have developed AM PravaH, a dedicated world's first all-inclusive 3D computational modelling software for Additive Manufacturing.

Brains behind this

Founded by Adwaith Gupta in 2020 in Bareilly, Uttar Pradesh, India. He earned his MS degree from Stanford University in the field of Fluid Mechanics and a BTech

degree from NIT Warangal. Prior to starting Paanduv Applications, Adwaith Gupta served as a senior Computational Fluid Dynamics (CFD) Engineer in the USA for half a decade. He led many global projects during his tenure as a CFD Engineer including the proliferation of physics-based modelling in the Additive Manufacturing industry; CFD code development and validation; scientific computing; coupling of Artificial Intelligence and CFD; technical marketing and creative data visualization. He also led a global academic program where he interacted with hundreds of students and faculty for establishing a common framework to promote computational modelling at the academic level. The team at Paanduv Applications Pvt. Ltd. consists of CFD software developers, application engineers, and research scientists with mostly PhDs from reputed institutes around the world.

Adwaith Gupta, Founder Paanduv

The Before and The After

The lack of an indigenous, yet globally the most accurate, low-cost high-end computational modelling software has been a serious concern. The imported CFD software has multiple problems including prohibitively high costs, hidden algorithms, unclear accuracy parameters, inappropriateness for researchers, and poor support.

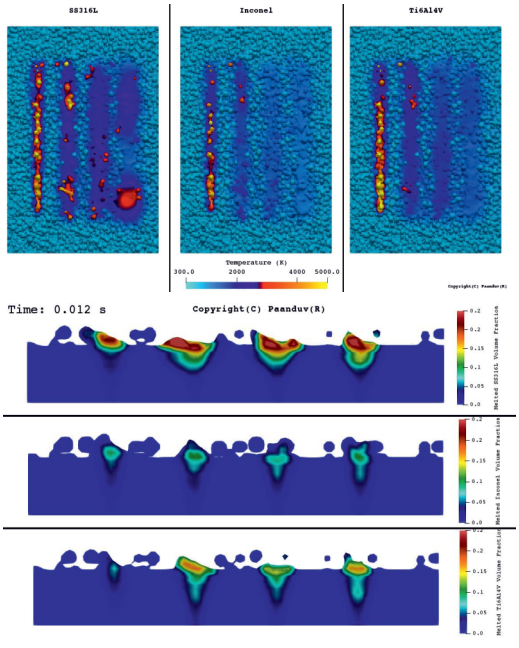
At Paanduv Applications,they developed AM PravaH which is a low-cost, indigenous, highly accurate, research and industry-centric computational software that would eliminate the severe restrictions posed by imported CFD software.

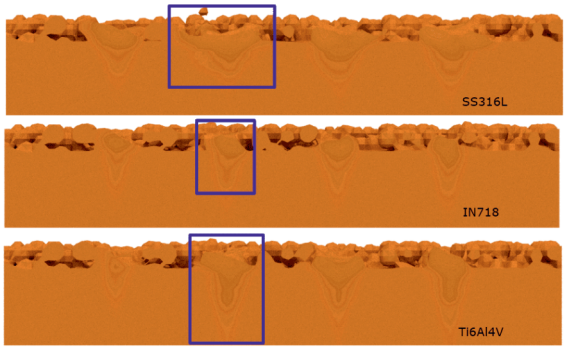
AM PravaH will assist users in developing economic builds, minimizing waste, material innovation, and process optimization, by not only using the physics-based modules available inside AM PravaH, but also the pure data-based advanced Artificial Intelligence modules that cater to experimentalists in real-time decision making.

Users can use AM PravaH for in-depth analysis of multilayer LPBF, DED, and Welding processes both at a macro and micro scale for metals and plastics.

Technology

A team of top experts that can take the most complicated physics concepts involved in Additive Manufacturing and put them into the hands of users in a digestible manner, is what makes Paanduv unique.





Running the show from a relatively humble, but comfortable and inexpensive, city like Bareilly, their team shares a common vision of 'sustainable' tech growth.

They seek

Open to all options but specifically looking for like-minded individuals who can assist in scaling AM PravaH through their network and business development.

Contact Details

Reach them at support@paanduv.com or give a call at +91 8218317925 or visit their website at www.paanduvapplications.com.

Even better, visit their beautiful office in Bareilly, India.

A Quick Recap

- Paanduv Applications Private Limited provides advanced physics-based computational modelling services, advanced software development, and training to companies and institutes in multiple industries.

- With Additive Manufacturing being one of the main industries of focus, they have developed AM PravaH, a dedicated world's first all-inclusive 3D computational modelling software for Additive Manufacturing.

- Founded by Adwaith Gupta in 2020 in Bareilly, Uttar Pradesh, India. He earned his MS degree from Stanford University in the field of Fluid Mechanics and a BTech degree from NIT Warangal. Prior to starting Paanduv Applications, Adwaith Gupta served as a senior Computational Fluid Dynamics (CFD) Engineer in the USA for half a decade.

- He led many global projects during his tenure as a CFD Engineer including the proliferation of physics-based modelling in the Additive Manufacturing industry; CFD code development and validation; scientific computing; coupling of Artificial Intelligence and CFD; technical marketing and creative data visualization.

- The team at Paanduv Applications Pvt. Ltd. consists of CFD software developers, application engineers, and research scientists with mostly PhDs from reputed institutes around the world.

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- Users can use AM PravaH for in-depth analysis of multilayer LPBF, DED, and Welding processes both

at a macro and micro scale for metals and plastics.

- A team of top experts that can take the most complicated physics concepts involved in Additive Manufacturing and put them into the hands of users in a digestible manner, is what makes Paanduv unique.

- Running the show from a relatively humble, but comfortable and inexpensive, city like Bareilly, their team shares a common vision of 'sustainable' tech growth.

- Paanduv is directly addressing the problem of the leakage of money to other countries from India and getting sub-par CFD software in imports. This is simply not sustainable for developing, or developed economies. With AM PravaH, users can improve their existing additive manufacturing processes without making a dent in their pockets while obtaining top-tier accurate results.

- The company has established a good name in and outside India in providing professional, accurate, and low-cost computational modelling services and products.

- Within a short span of lesser than two years, Paanduv is working with global giants like Meta and Vedanta.

- They have collaborated or are in the process of industry-academia collaboration with many academic institutes including IITs in India. Having successfully installed the first AM PravaH license at IIT Hyderabad, they anticipate many more installations to happen in the near future.

- Open to all options but specifically looking for like-minded individuals who can assist in scaling AM PravaH through their network and business development.

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Scaling Down Nissan's Concept Car

Ogle Models

The case study elaborates on the process adopted by Ogle Models for developing a one-third scale model of the concept car of Nissan Automobiles.

The motoring world was excited when Nissan unveiled its Ariya Single Seater Concept car using the powertrain of the all-electric Ariya SUV. The development of the ground-breaking bespoke single-seater car chassis, with its futuristic and sleek appearance, showed what a fully electrified performance motor could look like. Its Formula E design, with near 400-bhp and all-wheel drive, certainly turned heads when the public was given its first glimpse. With its aerodynamic wheel covers and bronze colouring, it was a unique sight.

Nissan global marketing divisional general manager for

brand and engagement, Juan Manuel Hoyos, was reported as saying at the time: "At Nissan, we dare to do what others don't." It was a fun project for the Japanese giants and they were keen to keep the vehicle on permanent display.

They wanted a one-third scale model of the concept car in the reception of their UK Design Centre in Paddington, London, and approached Ogle to create it after the Letchworth company had previously built full-size interior mock-ups of the first Qashqai and Juke models.

Process

The build took almost 500 hours, including the CNC machining, 3D printing and the painting with General Manager Dave Orman leading the project. The choice of material was governed by the weight and complexity of the parts with CNC and SLA processes used. After all the parts had been created, they were assembled with allowances made for the paint using magnets and screws. The model was attached to a plinth, before the whole thing was disassembled for painting and applying graphics.

With everything complete, the car was reassembled and finally secured to the plinth.

Challenges

It was quite a complex project. Because the CAD model had only A surface data, Ogle had to create the B surface which added thickness and features so something physical could be produced, ensuring that no undercuts were created, so the individual parts could all fit together like a jigsaw puzzle.

The team also had to consider whether the part was going to be CNC or SLA: The CAD for 3D printing is created as a solid model, whereas the CAD data for CNC machining can be a surface model.

Conclusion

Dave said: "We were extremely pleased with the finished model, which was made even more satisfying when we received such positive feedback from Nissan's design centre."

ABOUT THE AUTHOR

Ogle Models

One of the best reputations around, Ogle is a long established, Industrial Modelmaking, Rapid Prototyping and Industrial 3D Printing Company. Supporting the design and development process for a wide range of industry sectors including: Aerospace, Architectural, Automotive, Defence, Design, Medical and Renewable.

API published the 1st edition of Standard 20S for additive manufacturing of polymer-based components for the natural gas and oil industry

American Petroleum Institute

The article elaborates on API Standard 20T for Additively Manufactured Polymer-Based Components for Use in the Petroleum and Natural Gas Industries.

The American Petroleum Institute (API) today published a new standard on additive manufacturing (3D printing) for polymer-based components used in the natural gas and oil industry that will increase operating efficiency, ease supply chain issues and help reduce emissions.

"This new standard highlights the industry's success in leveraging new technologies and innovations to improve operations while supporting sustainability efforts," said API Vice President of Standards and Segment Services Alexa Burr. "Additive manufacturing can bring significant efficiency improvements that will

help the industry meet the world's demand for natural gas and oil."

API Standard 20T, Additively Manufactured Polymer-Based Components for Use in the Petroleum and Natural Gas Industries, specifies requirements for qualification in the manufacturing process, production, marking and documentation of 3D printed polymer-based components used in the industry.

The standard also provides guidance on how to test and document the material properties for the 3D printing of polymer-based components and introduces three additive manufacturing specification levels that define technical, quality and qualification requirements.

Additive manufacturing can help the natural gas and oil industry improve efficiency and productivity, cut lead times and supply chain stress, and streamline transportation and logistics because additive manufacturing takes place near the point of use.

Deploying 3D printing can help the industry reduce Scope 3 emissions when compared to traditional manufacturing, showing how innovation and technologies support API's Climate Action Framework, which details the industry's commitment to protect the environment by reducing greenhouse gas emissions.

20T is a complementary standard to the first edition of API Standard 20S, Additively Manufactured Metallic Components for Use in the Petroleum and Natural Gas Industries, published in late 2021. Focused on 3D printing of metallic components, 20S is first-of-its-kind for the industry and provides similar benefits as its sister standard on polymer-based components. A webinar covering both 20S and 20T has been scheduled for October 4, 2022. Registration information can be found here.

API represents all segments of America's natural gas and oil industry, which supports more than 11 million U.S. jobs and is backed by a growing grassroots movement of millions of Americans. Our approximately 600 members produce, process and distribute the majority of the nation's energy, and participate in API Energy Excellence®, which is accelerating environmental and safety progress by fostering new technologies and transparent reporting. API was formed in 1919 as a standards-setting organization and has developed more than 800 standards to enhance operational and environmental safety, efficiency and sustainability.

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AM NEWS

White House releases National Strategy for Advanced Manufacturing with special focus on 3D Printing

On the occasion of National Manufacturing Day, the White House released the National Strategy for Advanced Manufacturing. Manufacturing drives America's economy and national security. To help the United States remain a global leader, the Biden-Harris administration is focused on efforts that revitalize the manufacturing sector, build strong U.S. supply chains, invest in research and development (R&D), and train the workforce that will secure our global economic position. This quadrennial strategy outlines a vision for the U.S. to lead in advanced manufacturing — to grow the economy, create jobs, enhance environmental sustainability, address climate change, ensure national security and improve health care.

Through collaboration across the public and private sectors, the following goals and strategic objectives will be pursued during the next four years.

Goals

1. Develop and implement advanced manufacturing technologies.
2. Grow the advanced manufacturing workforce.
3. Build resilience into manufacturing supply chains and ecosystems.

Strategic Objectives

1. Enable clean and sustainable manufacturing to support decarbonization.
2. Accelerate manufacturing innovation for microelectronics and semiconductors.
3. Implement advanced manufacturing in support of the bioeconomy.
4. Develop innovative materials and processing technologies.
5. Lead the future of smart manufacturing.
6. Expand and diversify the advanced manufacturing talent pool.
7. Develop, scale and promote advanced manufacturing education and training.
8. Strengthen connections between employers and educational organizations.
9. Enhance supply chain interconnections.
10. Expand efforts to reduce supply chain vulnerabilities.
11. Strengthen and revitalize advanced manufacturing ecosystems.

Each of the objectives has detailed recommendations outlined in the strategy. As part of this "whole of government" approach, the recent passage of the CHIPS and Science Act invests in semiconductor infrastructure and will help support several of the objectives. The Inflation Reduction Act, in combination with the infrastructure modernization investments in the Bipartisan Infrastructure Law, will provide resources and incentives to help reach the climate and clean energy objectives. The president's Executive Order on Advancing Biotechnology and Biomanufacturing Innovation ensures a sustainable, safe and secure American bioeconomy.

Attaining these goals and objectives will require close collaboration across the U.S. government. Several agencies sponsor successful public-private partnerships, such as Manufacturing USA institutes

(funded in part by the U.S. Departments of Commerce, Defense and Energy and with support from six additional federal agency partners) and Manufacturing Extension Partnership (MEP) centers (funded and run by the National Institute of Standards and Technology). These are national resources that support and strengthen U.S. manufacturing and will play key roles in delivering on this strategy. For example, the Manufacturing USA institutes partner with other organizations on advanced manufacturing technology development and education and workforce development. In FY 2021, educational and workforce programs across Manufacturing USA trained more than 90,000 people, encouraging many to pursue careers in manufacturing. The MEP program assists small and medium-sized manufacturers, which make up most manufacturing enterprises in the U.S.

By investing in American advanced manufacturing, we invest in American communities. As technology advances manufacturing, innovations enable new, improved methods for making products as well as development of new products that improve our lives. Advances in manufacturing enable the economy to continuously grow as new technologies and innovations increase productivity, enable next-generation products, support our capability to address the climate crisis, and create new, high-quality, and higher-paying jobs.

IIT Hyderabad and DRDO join hands to set up industry-academia COE to work on advanced technologies including additive manufacturing

DRDO Cell was established in IIT Hyderabad (IITH) in 2020-21, which was working as a satellite Centre for the RIC Chennai (IIT Madras Research park). The then Director of the RIC, Dr Natrajan, took the initiative to contact various Defence Laboratories in and around Hyderabad, collate the problem statements, and share them among IITH faculty members through the then Dean (R&D) Prof Sumohana, IITH, and that's how the ball started rolling in 2019-20.

IITH Faculty and several DRDO Scientists put tireless efforts in first drafting the proposals to cater to the exact requirement of the Defense, and many proposals in varied areas ranging from Additive manufacturing to sensors design, Artificial intelligence to Space technologies were submitted, and 13 proposals worth of several Crores were sanctioned at the rocket speed. Understanding the importance of Additive Manufacturing to the Defence, one Centre for Additive Manufacturing was also proposed where faculty from various departments, from Mechanical to Materials science and Metallurgical Engineering, Biomedical to Electrical Engineering, participated. The currently sanctioned DIA COE will take this initiative to a higher level and enable IITH, DRDO, and Industry to contribute to nation-building. Dr Samir V Kamat, Chairman DRDO & Secretary DDR&D, exchanged MoU with Prof B S Murty, Director,

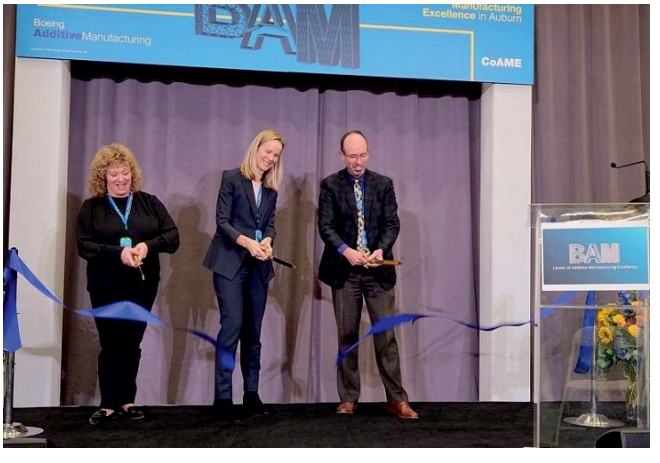
IITH, for setting up the DRDO Industry Academia Center of Excellence at IIT Hyderabad in the presence of Hon'ble Raksha Mantri Shri RajnathSingh during the largest Defence exhibition and conference DefExpo22, Gandhinagar on October 20, 2022. One Scientist of DFTM, DRDO HQrs, will be nominated as DFTM Coordinator. He/She will be responsible for coordinating between DRDO labs, and the host institute. other academic/ research institutes and industries for smooth & timely completion of activities of DIA-CoE. Expressing his delight on this milestone, Prof B S Murty, Director, IITH, "Country's defence is not only the responsibility of those who fight the battle on the border but also every Indian, who can be a significant contributor in their own way. IITH is committed to serving humanity through invention & Innovation in

technology; DIA-CoE is another indication of the high Innovation Quotient we are known for. IITH is among a few IITs that has been trusted for its capabilities and adored this unique opportunity to serve the nation profoundly".

The DIA CoE will work on the following broad domains: Ultra High-Temperature Materials for Hypersonic Vehicles, Artificial Intelligence for Missile and Missile Defence, Technologies for Space application, Adaptive Imaging and Image Processing Nanoornithocopter technologies , Seeker and Homing Technologies and Additive Manufacturing.

Boeing Marks Opening of Its Washington Additive Facility

Boeing has formally opened its new additive manufacturing facility in Auburn, Washington. The new Center of Additive Manufacturing Excellence (CoAME) leverages 3D printing technology in the design and manufacturing of tools and parts for commercial airplanes, helicopters, spacecraft, and satellites.



(From left) Auburn Mayor Nancy Backus, Melissa Orme, vice president of Boeing Additive Manufacturing, and Steve Chisholm, vice president and chief engineer for Boeing mechanical and structural engineering, symbolically cut a ribbon during the opening ceremony of Boeing's Center of Additive Manufacturing Excellence in Auburn, Washington, on September 23, 2022

"Additive manufacturing allows us to basically explore new ways of creating our products," Melissa Orme, vice president of Boeing Additive Manufacturing (BAM), said during the opening ceremony on September 23. "We can create parts that are not possible practically or traditionally."

The ability to 3D print tools and aircraft components gives Boeing a "competitive advantage," said Orme, because machinists can't typically create such items using traditional methods. 3D printing also can reduce the cost and weight of those structures while making them more robust and reliable, all while speeding the design and manufacturing process.

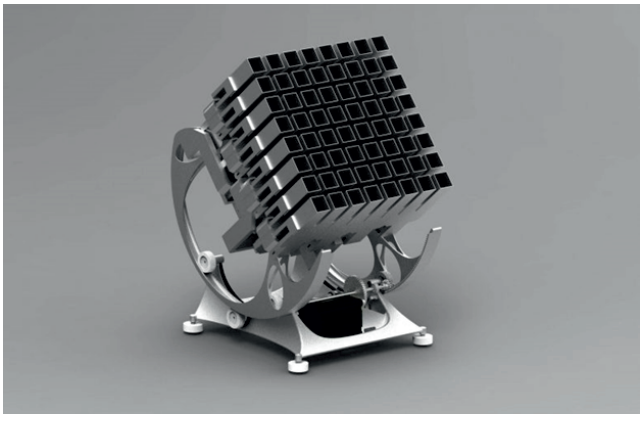
Additive manufacturing is also more environmentally friendly and sustainable than other methods because the process uses less energy and resources and creates fewer emissions, while waste materials created as byproducts of the process can be more easily recycled and reused. "So additive manufacturing really aligns with our company's commitment to reduce the global impact or the carbon footprint," Orme said.

The new BAM fabrication center actually opened for business in January 2020, but with little fanfare, as Boeing had to postpone the opening ceremony due to the Covid-19 pandemic. "So it's been a while since we've been doing this, but this is the first time we've had the opportunity to celebrate it," said Susan Champlain, director of government operations for Boeing's commercial airplanes.

While the facility is comparatively new, Boeing is not new to additive manufacturing. The company has used additive manufacturing for more than three decades, starting with tools and polymer-added parts for fighter aircraft. Boeing installed the first 3D-printed metal part in a commercial airplane, in the 787 Dreamliner. Today more than 70,000 additively manufactured parts appear in Boeing products, Orme said.

Nikon Announces Investment in 3D Printed Antenna Firm Optisys

Nikon Corporation (Nikon) announced an investment in Optisys, Inc. (Optisys), a global industry leader in the design and manufacture of metal printed antennas for



commercial and government applications where high performance, size, and weight are critical. The Optisys IP portfolio includes many proprietary antenna designs as well as revolutionary design improvements that support mass customization capabilities.

The demand for communications and radar antenna systems produced using metal additive manufacturing continues to grow as users recognize the benefits in size, weight, and power reduction (SWaP). Designing for metal 3D printing creates highly specialized components that provide enhanced performance. It also enables rapid modifications and simplifies integration of new features, while providing a net reduction in total parts by enabling multiple antenna components to be designed into a single piece. Optisys utilizes integrated design, manufacturing, and test processes to deliver cost-effective, tailored solutions in shorter development time, while ensuring critical product performance for the aerospace industry.

Nikon has long been recognized for manufacturing some of the most precise equipment ever made. Its products and technology are used in applications ranging from medical systems to satellites and automotive, as well as semiconductor processing and mass production of panels for TVs and a host of smart devices. By leveraging synergies resulting from global alliances and strategic investments with companies at the forefront of their industries, the Nikon Next Generation Project Division strives to accelerate growth in additive manufacturing and other pivotal technologies.

This investment will enable Nikon and Optisys to boost utilization of metal additive manufacturing for applications including high-performance antennas and other RF products. "This investment in Optisys is another central element of our Next Generation Project program to propel industrialization of digital manufacturing, "Yuichi Shibazaki, Nikon Corporate Vice President and General Manager of the Next Generation Project Division said. "Optisys' industry leadership and precision design and manufacturing capabilities are well-aligned with Nikon core technologies and our vision for the future. We look forward to partnering with their team to expand the additive manufacturing horizon."

Janos Opra, Chief Executive Officer of Optisys, said, "Nikon's investment and expertise in additive manufacturing and advanced manufacturing techniques gives Optisys access to an ecosystem where we will be able to produce high-performance printed antennas in commercial volumes. This will enable Optisys to bring additive manufactured antennas into the mainstream for the most demanding market segments in both commercial and government applications."

Adidas 4DFWD – The All New 3D Printed Running Shoe

Adidas takes a step into the future with the launch of the adidas 4DFWD, the company's most advanced 3D printed running shoe. The shoe is the first to break through a barrier that has long prevented runners from reaching their full potential. The shoe's industry-first bowtie-shaped lattice midsole transforms vertical pressure into horizontal force, providing runners with a non-stop smooth forward transition.

Adidas 4DFWD – The All New 3D Printed Running Shoe

Adidas evaluated over five million variations of the lattice structure and combined 18 years of real-world athlete performance data to identify a design that would change the game for runners around the world, making the impossible quest of creating the most

Above: adidas 4DFWD – the New 3D Printed Running Shoe/Source: adidas

technologically advanced running shoe yet a reality. Using 4D technology, adidas collaborated with its global innovation partner, Carbon's Digital Light Synthesis, to create a precisely fine-tuned midsole that provides a scientifically proven forward motion benefit.

To make the impossible quest of creating the most technologically advanced running shoe yet a reality, adidas evaluated over five million variations of the lattice structure and combined 18 years of real-world athlete performance data to identify a design that would change the game for runners around the world. Harnessing the power of 4D, adidas collaborated with its global innovation partner-Carbon's Digital Light Synthesis – to create a precisely fine-tuned midsole, which offers a scientifically proven forward motion benefit.

The new 4DFWD features:

- **Continental™ Outsole Introduced:** A new Continental™ outsole provides extra grip for a confident run in any weather condition

- **All-New Primeknit+ & Engineered Mesh Upper:** An all-new Primeknit+ and engineered mesh upper construction has been introduced for an extra-supportive and snug fit. Complemented by a new integrated heel counter, Primeknit+ offers a sock-like fit whilst areas of engineered mesh provide support exactly where runners need it most.

- **Unrivalled Comfort:** The 4DFWD midsole delivers 23% more cushioning than previous 4D midsole generations (the 4D Run 1.0)Anette (Peko) Hosoi, Neil and Jane Pappalardo Professor of Mechanical Engineering at the Massachusetts Institute of Technology, said, "When humans run, our forward motion is interrupted every time our foot hits the ground leading to a subtle stop-start motion between strides. This is true for all runners- no matter your ability. At the MIT Sports Lab, we are developing innovative technologies that offer a direct solution for overcoming that intrinsic challenge. And the new 4DFWD does just that."

"At adidas, we're always looking at the ways technology and data can intersect to create the best possible products for our runners. With the new 4DFWD, we made the impossible possible, challenging the laws of science by using a unique performance benefit designed to move you forward. With every stride, the midsole of the adidas 4DFWD turns vertical impact into horizontal forward motion for an unstoppable smooth forward transition and new underfoot experience throughout the run."

– Charlotte Heidmann, Product Manager at Adidas

The shoe will be available in a variety of colorways, including Carbon Cloud White, Impact Orange, and Grey Five for men and Grey Five and Cloud White for women. The shoe, available through adidas running shoes, is priced at €200 and will be available for purchase on September 1, 2022, with Early Access beginning on August 22 for members of the adidas Creators Club.

Bengaluru to soon have first 3D-printed post office in India

An entire post office is slated to come up in Karnataka, all in a span of just one month, thanks to 3D printing technology. The project will be completed by Larsen & Toubro Construction and cost 25% less than normal construction cost.

Cambridge Layout in Halasuru is set to witness this

picture for representational purposes

technological marvel, making it the first post office in the country to be built using 3D printing. Through this innovation, the construction cost would be reduced to one-fourth of the amount spent on a traditional model.
"We are keen on building low-cost post offices. Hence, we approached Larsen & Toubro Construction in connection with building our Halasuru Bazaar sub-post office. It is said to be the only company undertaking 3D printing-enabled construction in India," Chief Post Master General, Karnataka Circle, S Rajendra Kumar informed TNIE.

The Postal department has its own plot of land in Halasuru.

"A building of around 1,000 square feet here would cost less than Rs 25 lakh if 3D printing technology is used. This would work out to just 25 per cent of the normal construction cost," he said, adding that the technology could offer the department a feasible alternative to provide post office buildings in areas which desperately require them.

L&T has obtained technology approval from the Building Materials and Technology Promotion Council of the Ministry of Housing and Urban Affairs and IIT-Madras for 3D concrete printing for structures running from ground-plus-three floors, the CPMG said.

Asked about the time frame, Kumar said since this was being attempted for the first time in the country, certain procedural issues needed to be sorted out.

"As a rule, any contract running to over Rs 2.5 lakh must be opened up for competitive bidding. However, since this is likely to be the only concern eligible in this category, we could nominate them. We are verifying it and the work order may be issued to L&T within a month. They have already submitted designs to us and have assured us that the building would be ready in a month," he added.

University Grants Commission asked Higher Education institutions to explore "National Strategy on Additive Manufacturing (NSAM)" for integration in education

University Grants Commission asked the Higher Educational Institutions (HEIs) and its affiliated colleges to explore the initiation of suitable programmes and schemes in the thrust area of higher education based on the recommendations and actions identified in the National Strategy on Additive Manufacturing (NSAM).
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In a communique to the universities and colleges, it said that the "National Strategy on Additive Manufacturing (NSAM)" was released as part of Azadi ka Amrit Mahotsav by the Ministry of Electronics & Information Technology (MeitY). The NSAM has evolved to mitigate

immediate disabilities of the local industries to embrace digital technologies and to cater nation's aspiration of Manufacturing Value to US$ 1 Trillion per annum.

NSAM has identified key areas, where innovation and Research and development ecosystem would be created in Public and Private Partnership mode to transform the existing R&D knowledge base to develop AM-grade materials, 3D printer machines and printed indigenous products for the vast domestic and international market. The NSAM aspires to postulate the tenets of 'Make in India' and 'Atma Nirbhar Bharat Abhiyan' that advocate self-reliance through the technological transformation of the production paradigm with the participation of State governments, academia, industry and other stakeholders.

All the HEIs and their affiliated colleges and institutions are requested to explore the initiation of suitable programmes and schemes in the thrust area of higher education. It was based on the recommendations and actions identified in the NSAM to adopt and nurture Additive Manufacturing technologies in the departments based on the recommendations in the NSAM as part of Azadi Ka Amrit Mahotsav. Against this backdrop, the UGC asked to heads of the colleges and universities to take necessary initiatives to give effect to the NSAM.

CELLINK establishes Centre of Excellence in India with a focus on 3D bioprinting

The Centre of Excellence (CoE) will be focused on advancing research across heart, bone, cartilage and cancer research through the use of 3D bioprinting.

CELLINK, a global leader in the developing of 3D bioprinters, and The Indian Institute of Science (IISc) are partnering to establish a Centre of Excellence (CoE) for 3D bioprinting in Bengaluru, India.

The CoE, the first of its kind in the area, will be housed at the Centre for BioSystems Science and Engineering (BSSE) at IISc.

The Centre of Excellence will provide access to 3D bioprinting systems, enabling researchers to accelerate their work across critical applications with the ultimate goal of improving health outcomes.

"We are excited to host this CoE in the institute, which will help to initiate cutting-edge research in an emerging field of technology with immense potential to benefit human health," said Professor Narendra Dixit, Chairperson of BSSE.

3D bioprinting is the application of additive manufacturing techniques to live cells, growth factors and/or biomaterials to fabricate biomedical parts, often with the aim to mimic natural tissue characteristics.

A wide range of bioprinting techniques and biomaterials are covered by 3D bioprinting. It can currently be used to print tissue and organ models that help research drugs and potential treatments.

Several CELLINK 3D bioprinters will be housed at the new CoE. It will serve as a hub for several research initiatives and training activities within the technology. IISc and CELLINK will work together to conduct workshops aimed at providing researchers within the institute, and elsewhere, the skills necessary to utilise 3D bioprinting.

The two groups will also undertake and advise on research projects across multiple applications spanning the fields of tissue engineering, drug discovery, material science and regenerative/personalised medicine. The CoE will have a focus on work around the heart, bone cartilage and cancer.

"It's an honour to collaborate with one of the most prominent science institutes in India. India has long been at the forefront of scientific discovery, and with the exceptional talent and deep-rooted passion to translate research from the benchtop to the clinic, we are confident that this Centre of Excellence will make a lasting impact on the progress within research in the fields of heart, bone, cartilage and cancer," said Cecilia Edebo, CEO of CELLINK.

Bengaluru is also home to a new state-of-the-art 3D printing facility at Bengaluru Airport City. The facility houses a production centre and an experience zone that will train individuals and students in 3D printing. It will also be an incubation centre for those who want to ideate new solutions.

Wild 3D-printed space habitat prototype designed to fit inside SpaceX Starship lands in Switzerland

SAGA Space Architects partnered with school-aged Swiss students to bring a light-infused look to moon or Mars exploration. Perched in a Swiss experimental park is a space habitat inspired by SpaceX's Starship.

The Rosenberg Space Habitat is as an experimental lab for students designed to fit in a SpaceX Starship (Image credit: Institut auf dem Rosenberg)

School-aged students at Institute auf dem Rosenberg, between ages 6 and 18, worked for years on a prototype for future astronauts that would fit inside the shell of SpaceX's powerful Starship rocket.

The results, unveiled on Wednesday (July 20), show a light-infused structure created in partnership with Danish architecture firm SAGA Space Architects. The three-story building includes dedicated spots for analog astronauts to work and relax.

In the coming years, students will complete "immersive learning modules" inside of the habitat. They will work inside what is said to be the world's tallest 3D-printed polymer structure at a height of 23 feet (7 meters), the institute said in a statement(opens in new tab) timed to coincide with the 53rd anniversary of the first human moon landing.

"Our aim is to provide future leaders with early exposure to the question of advanced space exploration, allowing our students to approach and solve ... complex questions from a collaborative and holistic point of view," Bernhard Gademann, director general of Rosenberg, said in the statement.

The three-floor Rosenberg Space Habitat prototype includes dedicated areas for work and rest, to promote crew well-being (Image credit: Institut auf dem Rosenberg)

The Rosenberg Space Habitat took two years to create from "initial creative concepts and paper models," the institute said. Industrial partners assisted, with the 3D-printed outer shell created in Milan and the interior structure made in Copenhagen.

Using polymer in 3D printing was a deliberate choice, but somewhat unique, as "it provides more versatility than concrete that is used in most 3D printed structures." In anticipation of high ultraviolet (UV) radiation on the surface of the moon(opens in new tab) or Mars(opens in new tab), the material does have a UV stabilizer to make it more durable. However, the habitat

can also be broken down and the polymer reused to make a new structure if required.

Add-ons for student missions include a robot, called Spot, and multi-functional furniture allowing residents to make the most of cramped quarters.

Institut auf dem Rosenberg students and SAGA Space Architects designed the Rosenberg Space Habitat to house two crew members with plenty of space and light.
(Image credit: Institut auf dem Rosenberg)

Planned investigations, Rosenberg stated, will examine hardware, software, remote mission control systems and "sensory stimulation" including light, sound and smell. Students will also participate in projects meant to simulate "systems thinking" (how a a complex system interrelates between its parts) and to work in artificial intelligence.

Rosenberg added that they hoped the in-house investigations in their habitat would benefit future lunar explorers, as it will show students "not to fear new technology, but to embrace it and design it to its next generation."

First 9-meter-high 3D printed villa built in Saudi Arabia

Dar Al Arkan, Saudi Arabia's leading real estate company, has launched the first 3D construction printed (3DCP) two-story, 9.9-meter-high villa in the kingdom at the Shams Al Riyadh residential development. Notably, the villa was built directly on site, without any AC equipment during the summer. Construction followed strict protocols to ensure that the villa is being built safely in every aspect as per Saudi Arabia's building codes.

The use of 3CDP technology is the first of its kind in this area as it accelerates the pace of construction while reducing the wastage of construction material, increasing safety, and reducing errors. Saudi Arabia has used this technology to meet the goals of Saudi Vision 2030 and to support economic diversification and digitization. Unlike traditional home-building methods, 3DCP cuts construction time by more than half is more flexible, and requires less manpower because only three workers are needed to build a house. Additionally, less concrete is required to complete the building making the technology a more sustainable and viable solution for the low-carbon construction industry of the future.

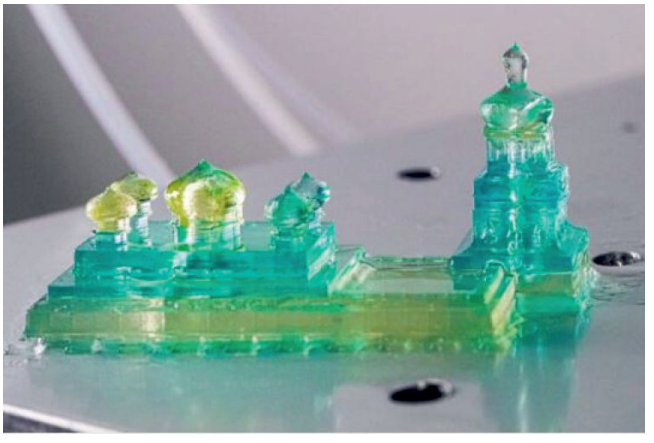
Project Manager Wael Al Hogan said:

"Our company is building a second villa, which would normally take a month to complete, but we have already completed the first floor in just eight days. These 3D-printed villas have additional insulation layers and features that ensure energy conservation, saving up to 30 percent in energy consumption.

"With this technological revolution, customers will be able to choose from a variety of digital designs when buying their villas in the near future and with just a click of a button you will be able to print your home."

Research and Development News

New 3D printing method designed by Stanford engineers promises faster printing with multiple materials



A model of Kyiv's Saint Sophia Cathedral in the blue and yellow of the Ukrainian flag, made using the iCLIP method for 3D printing, which allows for the use of multiple types – or colors – of resin in a single object. (Image credit: William Pan)

Stanford engineers have designed a method of 3D printing that is 5 to 10 times faster than the quickest high-resolution printer currently available and is capable of using multiple types of resin in a single object.

Advancements in 3D printing have made it easier for designers and engineers to customize projects, create physical prototypes at different scales, and produce structures that can't be made with more traditional manufacturing techniques. But the technology still faces limitations – the process is slow and requires specific materials which, for the most part, must be used one at a time.

Researchers at Stanford have developed a method of 3D printing that promises to create prints faster, using multiple types of resin in a single object. Their design, published recently in Science Advances, is 5 to 10 times faster than the quickest high-resolution printing method currently available and could potentially allow researchers to use thicker resins with better mechanical and electrical properties.

"This new technology will help to fully realize the potential of 3D printing," says Joseph DeSimone, the Sanjiv Sam Gambhir Professor in Translational Medicine and professor of radiology and of chemical engineering at Stanford and corresponding author on the paper. "It will allow us to print much faster, helping to usher in a new era of digital manufacturing, as well as to enable the fabrication of complex, multi-material objects in a single step."

Controlling the flow of resin

The new design improves on a method of 3D printing created by DeSimone and his colleagues in 2015 called continuous liquid interface production, or CLIP. CLIP printing looks like it belongs in a science fiction movie – a rising platform smoothly pulls the object, seemingly fully formed, from a thin pool of resin. The resin at the surface is hardened into the right shape by a sequence of UV images projected through the pool, while a layer of oxygen prevents curing at the bottom of the pool and creates a "dead zone" where the resin remains in liquid form.

The dead zone is the key to CLIP's speed. As the solid piece rises, the liquid resin is supposed to fill in behind it, allowing for smooth, continuous printing. But this doesn't always happen, especially if the piece rises too quickly or the resin is particularly viscous. With this new method, called injection CLIP, or iCLIP, the researchers have mounted syringe pumps on top of the rising platform to add additional resin at key points.

"The resin flow in CLIP is a very passive process – you're just pulling the object up and hoping that suction can bring material to the area where it's needed," says Gabriel Lipkowitz, a PhD student in mechanical engineering at Stanford and lead author on the paper. "With this new technology, we actively inject resin onto

the areas of the printer where it's needed."

The resin is delivered through conduits that are printed simultaneously with the design. The conduits can be removed after the object is completed or they can be incorporated into the design the same way that veins and arteries are built into our own body.

Multi-material printing

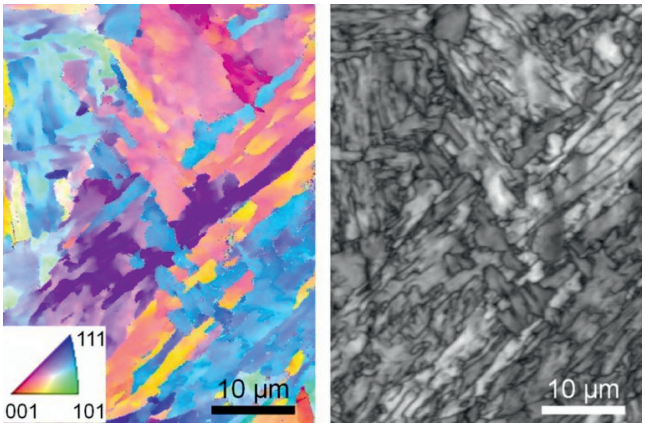
By injecting additional resin separately, iCLIP presents the opportunity to print with multiple types of resin over the course of the printing process – each new resin simply requires its own syringe. The researchers tested the printer with as many as three different syringes, each filled with resin dyed a different color. They successfully printed models of famous buildings from several countries in the color of each country's flag, including Saint Sophia Cathedral in the blue and yellow of the Ukrainian flag and Independence Hall in American red, white, and blue.

"The ability to make objects with variegated material or mechanical properties is a holy grail of 3D printing," Lipkowitz says. "The applications range from very efficient energy-absorbing structures to objects with different optical properties and advanced sensors."

Having successfully demonstrated that iCLIP has the potential to print with multiple resins, DeSimone, Lipkowitz, and their colleagues are working on software to optimize the design of the fluid distribution network for each printed piece. They want to ensure that designers have fine control over the boundaries between resin types and potentially speed up the printing process even further.

"A designer shouldn't have to understand fluid dynamics to print an object extremely quickly," Lipkowitz says. "We're trying to create efficient software that can take a part that a designer wants to print and automatically generate not only the distribution network, but also determine the flow rates to administer different resins to achieve a multi-material goal."

Researchers Uncover How to 3D-Print One of the Strongest Stainless Steel



A microscopic image of 3D-printed 17-4 stainless steel. The colors in the left-side version of the image represent the differing orientations of crystals within the alloy. Credit: NIST

A team of researchers from the National Institute of Standards and Technology (NIST), the University of Wisconsin-Madison and Argonne National Laboratory has identified particular 17-4 steel compositions that, when printed, match the properties of the conventionally manufactured version. The researchers' strategy, described in the journal Additive Manufacturing, is based on high-speed data about the printing process they obtained using high-energy X-rays from a particle accelerator

For airliners, cargo ships, nuclear power plants and other critical technologies, strength and durability are essential. This is why many contain a remarkably strong and corrosion-resistant alloy called 17-4 precipitation hardening (PH) stainless steel. Now, for the first time ever, 17-4 PH steel can be consistently 3D-printed while retaining its favorable characteristics.

The new findings could help producers of 17-4 PH parts use 3D printing to cut costs and increase their manufacturing flexibility. The approach used to examine the material in this study may also set the table for a better understanding of how to print other types of materials and predict their properties and

performance.

Despite its advantages over conventional manufacturing, 3D-printing of some materials can produce results that are too inconsistent for certain applications. Printing metal is particularly complex, in part because of how quickly temperatures shift during the process.

"When you think about additive manufacturing of metals, we are essentially welding millions of tiny, powdered particles into one piece with a high-powered source such as a laser, melting them into a liquid and cooling them into a solid," said NIST physicist Fan Zhang, a study co-author. "But the cooling rate is high, sometimes higher than one million degrees Celsius per second, and this extreme nonequilibrium condition creates a set of extraordinary measurement challenges."

Because the material heats and cools so hastily, the arrangement, or crystal structure, of the atoms within the material shifts rapidly and is difficult to pin down, Zhang said. Without understanding what is happening to the crystal structure of steel as it is printed, researchers have struggled for years to 3D-print 17-4 PH, in which the crystal structure must be just right — a type called martensite — for the material to exhibit its highly sought-after properties.

The authors of the new study aimed to shed light on what happens during the fast temperature changes and find a way to drive the internal structure toward martensite.

Just as a high-speed camera is needed to see a hummingbird's flapping wings, the researchers needed special equipment to observe rapid shifts in structure that occur in milliseconds. They found the right tool for the job in synchrotron X-ray diffraction, or XRD.

"In XRD, X-rays interact with a material and will form a signal that is like a fingerprint corresponding to the material's specific crystal structure," said Lianyi Chen, a professor of mechanical engineering at UW-Madison and study co-author.

At the Advanced Photon Source (APS), a powerful light source at the Department of Energy's Argonne National Laboratory, the authors smashed high-energy X-rays into steel samples during printing.

The authors mapped out how the crystal structure changed over the course of a print, revealing how certain factors they had control over — such as the composition of the powdered metal — influenced the process throughout.

While iron is the primary component of 17-4 PH steel, the composition of the alloy can contain differing amounts of up to a dozen different chemical elements. The authors, now equipped with a clear picture of the structural dynamics during printing as a guide, were able to fine-tune the makeup of the steel to find a set of compositions including just iron, nickel, copper, niobium and chromium that did the trick.

"Composition control is truly the key to 3D-printing alloys. By controlling the composition, we are able to control how it solidifies. We also showed that, over a wide range of cooling rates, say between 1,000 and 10 million degrees Celsius per second, our compositions consistently result in fully martensitic 17-4 PH steel," Zhang said.

As a bonus, some compositions resulted in the formation of strength-inducing nanoparticles that, with the traditional method, require the steel to be cooled and then reheated. In other words, 3D printing could allow manufacturers to skip a step that requires special equipment, additional time and production cost.

Mechanical testing showed that the 3D-printed steel, with its martensite structure and strength-inducing nanoparticles, matched the strength of steel produced through conventional means.

The new study could make a splash beyond 17-4 PH steel as well. Not only could the XRD-based approach be used to optimize other alloys for 3D printing, but the

information it reveals could be useful for building and testing computer models meant to predict the quality of printed parts.

"Our 17-4 is reliable and reproducible, which lowers the barrier for commercial use. If they follow this composition, manufacturers should be able to print out 17-4 structures that are just as good as conventionally manufactured parts," Chen said.

Paper: Q. Guo, M. Qu, C.A. Chuang, L. Xiong, A. Nabaaa, Z.A. Young, Y. Ren, P. Kenesei, F. Zhang, and L. Chen. Phase transformation dynamics guided alloy development for additive manufacturing. Additive Manufacturing. Published online Aug. 2, 2022. DOI: 10.1016/j.addma.2022.103068

Researchers develop drones that can 3D print while flying

Researchers have created a team of drones that can 3d print while they are flying. These flying robots can coordinate and make decisions about how to print objects that are bigger than themselves – expanding the horizons of the construction industry.

Previous trials of using 3D printing for construction involved ground-based robots, which lacked agility. To solve this, the researchers looked to mimic natural builders such as bees and wasps. Because their drones can print while flying, they can also build in hard-to-reach places and hostile environments.

Study first-author Dr Ketao Zhang, Lecturer in Robotics at Queen Mary University of London, said: 'Natural systems have long been sources of inspiration for engineers making smart artificial machines. The specialist structural engineers in nature – and their construction approach in building their habitats – are very scalable and adaptable.

For now, we've shown that it's possible for flying robots to build and repair structures. This is an exciting step in robotics. The homes and cities of the future could be built with the help of autonomous robots.'

To perform the tasks they wanted, the drones needed to be able to follow a printing path strategy, to assess the quality of their work, to broadcast their activities to one another, and to autonomously make decisions in response to external and team factors.

The researchers behind the robots, led by Imperial College London and Empa, the Swiss Federal Laboratories of Materials Science and Technology, as well as Queen Mary University of London and others, have called the approach Aerial Additive Manufacturing (Aerial-AM), in a paper published in Nature.

Autonomous decision-making

The researchers for the first time developed scalable swarm-based control system for Aerial-AM using multiple autonomous drones while flying. They used the multi-disciplinary physical artificial intelligence development method to enable the drones to behave like a team of builders.

The researchers achieved this by using 'BuilDrones' to print cementitious materials, while 'ScanDrones' assessed the work and instructed the BuilDrones. The drones were capable of live autonomous task allocation, spatial collision awareness, and making decisions about how to work effectively.

For example, during one experiment some of the drones decided to retire themselves, because there

were too many of them in the available space.

The teams of drones were able to print large-scale geometrical objects including a 2m high cylinder made of a polyurethane-based foam material, and an 18-centimetre-high cylinder with a custom-designed structural cement-like material.

Reducing emissions

The Aerial-AM approach promises to help the construction industry adapt and respond to climate change. It could also help tackle the problem of labour shortages in the sector.

Dr Zhang said: 'This new approach, involving minimal transport beyond raw material supplies, offers a promising solution for reducing global CO2 emissions and materials waste generated by the construction industry.

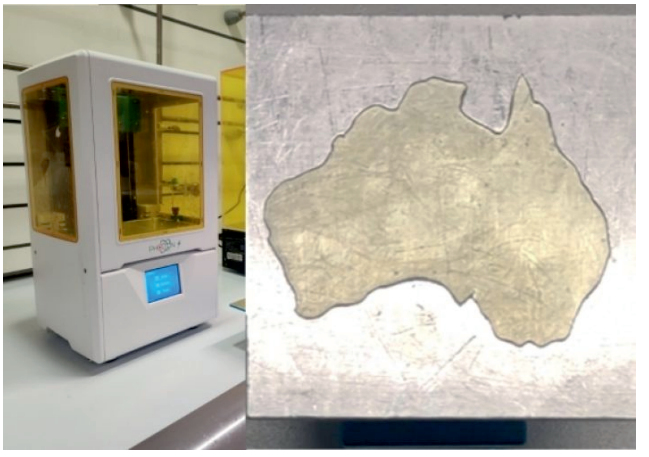
The construction industry is increasingly adopting robotics-based technologies. These are increasing productivity and reducing human-labour in hazardous and labour-intensive tasks in the sector.'

This work was funded by the Engineering and Physical Sciences Research Council (part of UKRI), the Royal Society, the European Commission's Horizon 2020 Programme, Royal Thai Government Scholarship and a University of Bath Research Scholarship. The project is also supported by Industrial Partners Skanska, Ultimaker, Buro Happold, and BR.

Co-investigators include Robert Stuart-Smith, Stefan Leutenegger, Vijay Pawar, Richard Ball, Chris Williams and Paul Shepherd, and their research teams at UCL, University of Bath, University of Pennsylvania, Queen Mary University of London, and University of Munich.

The research was launched by Assistant Professor Stuart-Smith at UCL and University of Pennsylvania and Professor Kovac at Imperial and Empa after a pilot research collaboration and award for a demonstration on pipeline repair.

UNSW Sydney Researchers develop new 3D printing process that offers novel energy storage design options



Researchers at UNSW Sydney used a standard 3D printer to produce an intricate map of Australia made of solid polymer electrolyte which was then tested as an energy storage device.
Photos from Dr Nathaniel Corrigan

A team from University of New South Wales (UNSW) Sydney has developed a way to 3D print strong, high-conducting solid polymer electrolytes into custom shapes.

UNSW engineers have developed a process to print solid-state polymer electrolytes into any shape desired for use in energy storage.

The research team from the School of Chemical Engineering led by Professor Cyrille Boyer, including Dr Nathaniel Corrigan and Kenny Lee – say the 3D printing process of such material could be particularly useful in future medical devices where small, intricately designed energy storage offers a number of benefits.

Solid-state electrolytes are a key component in solid-state batteries, although traditionally they have suffered from poor performance due to low ionic conductivities or poor mechanical properties.

However, in a paper published in Advanced Materials, the team from UNSW reports their 3D printed solid

polymer electrolyte (SPE) offers high conductivity, as well as robust strength.

This means the solid-state electrolytes can potentially be used as the actual structure of a device, creating a range of conceivable design opportunities, particularly for future medical products.

"Nobody has 3D printed solid polymer electrolytes before. Traditionally they have been made using a mould, but previous processes did not offer the ability to control the strength of the material, or to form it into complex shapes," says Kenny Lee.

"With existing solid-state electrolytes when you increase the mechanical strength of the material, you sacrifice a lot of the conductivity. If you want higher conductivity the material is much less robust. What we have achieved is a simultaneous combination of both, which can be 3D printed into sophisticated geometries.

"This polymer electrolyte has the potential to be a load-bearing energy storage material. Because of its strength, it could be used as the actual structure of small electronics, or in aerospace applications, or in small personal medical devices given our 3D printing process can be very intricate and precise.

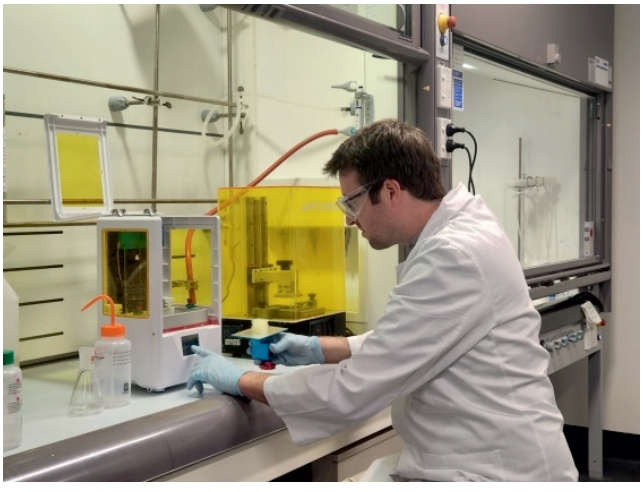
"We can create really tiny structures with the kind of systems we're using. So it has fantastic application in nanotechnology and anywhere you need to design energy storage on a micro-scale level."

Increased cycling stability

Although the solid polymer electrolyte developed by the UNSW team is regarded as a high-performance material, the researchers say it can be manufactured using inexpensive and commercially available 3D printers, rather than sophisticated engineering equipment.

The SPE described in the paper is composed of nano-scale ion-conducting channels embedded in a rigid crosslinked polymer matrix. It is produced via a process known as polymerization-induced microphase separation (PIMS).

To showcase the versatility of the material, the researchers 3D printed an intricate map of Australia which was then tested as an energy storage device.



UNSW researcher Dr Nathaniel Corrigan working with a 3D printer in the laboratory. Photo from Dr Corrigan

"One of the other benefits of this SPE in energy storage devices is the fact it increases the cycling stability – that is the number of charging and discharging cycles until its capacity is reduced to a certain amount," says Dr Corrigan.

"In our paper, we show that this material is very stable and has the ability to charge and discharge over thousands of cycles. After 3000 cycles there was only roughly a 10 per cent drop."

The researchers say 3D printing also reduces wastage compared to other traditional forms of manufacturing and reduces costs since the same machine can be used to produce a variety of differently shaped materials.

In future, they say product designers could utilise their SPE to create items with a much higher energy storage density.

"Imagine an earpod predominantly made out of this material, which is also acting as the battery. The storage density will be much higher and the power would

therefore last longer," says Professor Boyer.

"We really hope to be able to push forward in terms of commercialisation because we've created some really incredible materials and processes."

3D printed glasses developed by researchers at Khalifa University could be the cure for color blind people

Looking through glasses to bleach nature landscape with blue sky and yellow field.

A team of researchers from Khalifa University has developed a new wearable that could help people with color blindness. While using dyes to develop lenses for glasses to help correct colorblindness is not new, the team has developed a method using 3D printing to manufacture customized glasses.

Dr. Haider Butt, Associate Professor of Mechanical Engineering, Dr. Fahad Alam, Postdoctoral Fellow, Dr. Mohamed Elsherif, Postdoctoral Fellow, and Ahmed Salih, all Department of Mechanical Engineering, published their results in Advanced Engineering Materials. This research also inspired a Senior Design Project for undergraduate students Saif Abdulla Alnaqbi, Ali Saif Rashid Alshawi Aleghfeli, Rashid Ali Khalfan Bin Gahfan Al Ali, and Mohammad Ali Mohamad Hussain Ali Alshamali.

A transprent resin was used to make the lenses, mixed with two wavelength-filtering dyes to provide a tinting effect. The researchers used three different concentrations of the dyes to customize the lenses and compared their 3D-printed glasses to commercially available products used to treat color vision deficiency (CVD).

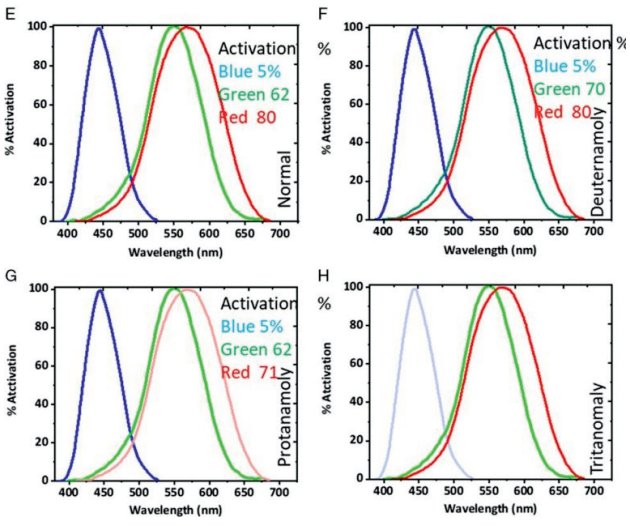
"Patient-specific customization of glasses for CVD remains a challenge, even though research has significantly advanced the properties and materials of CVD wearables available on the market," Dr. Butt said.

Problems with distinguishing between shades of certain colors restrict people from working in fields where color recognition is critical, but can also have everyday ramifications as simple as deciding whether a banana is ripe or selecting matching clothes.

The retina of the eye has three types of cones: One perceives blue light, another green, and the third red. These cones work together to allow people to see the whole spectrum of colors, but CVD is an inherited ocular disorder that limits this ability. Red-green color blindness is the most prevalent form of CVD, with most sufferers relying on wearables to manage the difficulties in day-to-day tasks. The most common wearable is a form of tinted glass.

Deuteranomaly, which occurs mostly in men, is a condition in which the photoreceptor responsible for detecting green light responds to light associated with red. This can be improved using red-tinted glasses, which make the colors more prominent. Certain dyes can absorb and filter out some of the wavelengths between green and red that confuse the photoreceptors. With less color overlap, the brain gets a clearer signal to help distinguish between the problem colors. This concept can also be extended to the other forms of CVD.

The KU team used two dyes: One blocked the undesired wavelengths for red-green patients, while the other filtered unwanted wavelengths for yellow-blue patients. The team used both dyes in their lenses, and when tested, volunteers with red-green CVD and yellow-blue CVD both benefited from the glasses, suggesting their efficacy at managing both CVD types.



The activation of the photoreceptor cells at 520 nm for E) normal, F) deutan, G) protan, and H) tritan.

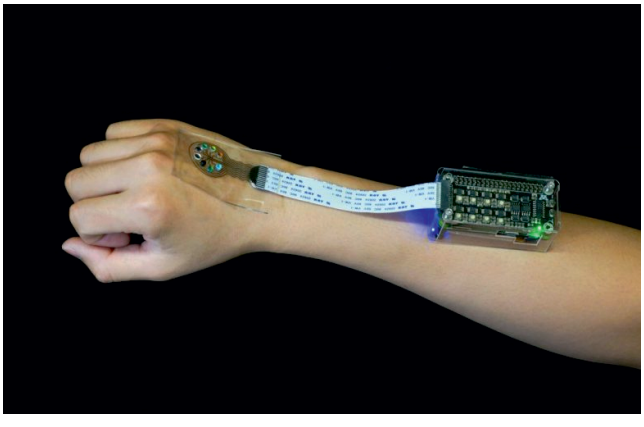
Glasses based on this approach are commercially and readily available, but they are bulky and can be uncomfortable. The KU research team developed their own frames for their lenses, using 3D printing to optimize the frames for comfort and usability. Inspired by commercially available designs, their 3D printed glasses can fold like other glasses, making them more usable to the wearer.

Research on CVD-management techniques has shown that using dyes can be difficult as leaching and toxicity problems can occur, however the research team tested this to ensure their glasses were safe for long-term use. The stability of the dyes within the 3D printed glasses was examined by storing the glasses in water over a week. Their results showed that no dye leaked into the water, indicating their stability. They also left the glasses open at ambient conditions for a further week, proving their stability and long-lasting properties.

Their mechanical properties were also carefully assessed. Their flexibility and tensile strength are crucial components in quantifying their longevity and durability, and when tested, the glasses exhibited excellent durability, without breaking even when subjected to folding or bending.

"Our results showed that 3D printing had no influence on the wavelength-filtering properties of the dyes," Dr. Butt said. "In fact, the dyes remained unchanged as they were integrated with the resin and 3D printed. When we compared the optical performance of our glasses with commercial colorblind glasses, our results indicated that our 3D-printed glasses were more selective in filtering undesired wavelengths than the commercially available options. They have great potential in treating colorblindness, and their ease of fabrication and customization means they can be tailored to each individual patient."

A unique 3D-printed light-sensitive device could help people with lupus



A unique 3D-printed light-sensitive medical device could help millions of people worldwide with lupus and other light-sensitive diseases by providing access to real-time data for more personalized treatment. Credit: McAlpine Group, University of Minnesota

A team of engineers and doctors at the University of Minnesota Twin Cities has developed a unique 3D-printed light-sensitive medical device that sits directly on the skin and provides real-time feedback to correlate light exposure with disease progression. The device could help millions of people worldwide with lupus and other light-sensitive diseases by providing access to more personalized treatments and information to determine what's causing their symptoms.

The study was published in Advanced sciences, an interdisciplinary, award-winning, open-access scientific journal. The researchers have also filed a patent for the

device, and the technology is available for licensing.

According to the Lupus Foundation of America, about 1.5 million Americans and at least 5 million people worldwide have some form of lupus. Sensitivity to light is common in people with lupus, with 40 to 70 percent of people with lupus finding that their disease worsens when exposed to sunlight or even indoor artificial light. Symptoms of these flare-ups in lupus patients include rash, joint pain, and fatigue.

"I treat many patients with lupus or related conditions, and clinically it is difficult to predict when a patient's symptoms will worsen," said Dr. David Pearson, a dermatologist at the University of Minnesota School of Medicine and co-author of the study. "We know that ultraviolet light and, in some cases visible lightcan cause flare-ups of symptoms – both on the skin and internally – but we don't always know which combinations of light wavelengths contribute to symptoms."

Pearson heard about the groundbreaking, customized wearable 3D printing developed by University of Minnesota mechanical engineering professor Michael McAlpin and his team, and contacted him to collaborate on a solution to his problem.

McAlpine's research team worked with Pearson to develop a first-of-its-kind fully 3D-printed device with a flexible UV-visible light detector that can be placed on the skin. The device is integrated with a dedicated portable console for continuous monitoring and correlation lighting to symptoms.

"This research builds on our previous work, in which we developed a fully 3D-printed light-emitting device, but this time instead of emitting light, it receives light," said McAlpine, co-author of the study and the Courmeier Family Professor of the Department mechanical engineering. "To measure it, the light is converted into electrical signals, which can then be correlated with the worsening of the patient's symptoms."

McAlpine said developing the device, however, was no easy task. The 3D-printed device consists of several layers of materials printed on a biocompatible silicone base. The layers include electrodes and optical filters. Filters can be changed depending on the wavelength of light to be evaluated. The research team also used zinc oxide collect ultraviolet (UV) light and convert it into electrical signals. The device is mounted on the cover, and a special console is attached to collect and store data.

Author: University of Minnesota
The research team has received approval to begin testing the device on humans and will soon begin recruiting participants for the study.

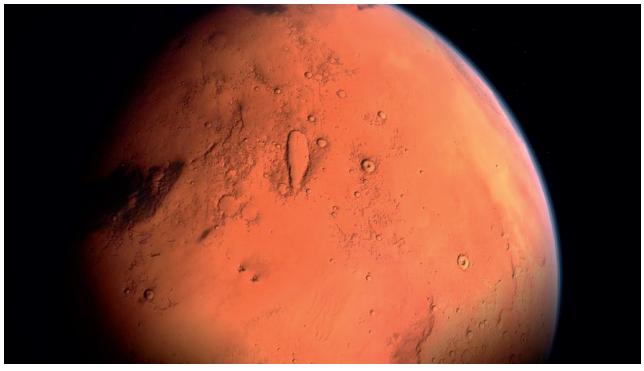
"We know these devices work in the lab, but our next step is to put them in the hands of patients to see how they work in real life," Pearson said. "We can give them to participants and track what light they've been exposed to and determine how we can predict symptoms. We'll also continue testing in the lab to improve the device."

McAlpine and Pearson said the 3D printing process is relatively inexpensive and could someday provide easy and quick access to a device without the expensive manufacturing processes of traditional devices.

"At the moment, there is no other device like it with this potential for personalization and this easy to manufacture," Pearson said. "I dream of having one of these 3D printers right in my office. I could see the patient and judge what wavelength of light we want to judge. Then I could just print it out for the patient and give it to them. be 100 percent personalized to their needs. This is where the future of medicine is going."

Martian rock-metal composite shows potential of 3D printing on Mars

A small amount of simulated crushed Martian rock mixed with a titanium alloy made a stronger, high-performance material in a 3D-printing process that could one day be used on Mars to make tools or rocket



parts. The parts were made by Washington State University researchers with as little as 5% up to 100% Martian regolith, a black powdery substance meant to mimic the rocky, inorganic material found on the surface of the red planet. While the parts with 5% Martian regolith were strong, the 100% regolith parts proved brittle and cracked easily. Still, even high-Martian content materials would be useful in making coatings to protect equipment from rust or radiation damage.

A little Martian dust appears to go a long way. A small amount of simulated crushed Martian rock mixed with a titanium alloy made a stronger, high-performance material in a 3D-printing process that could one day be used on Mars to make tools or rocket parts.

The parts were made by Washington State University researchers with as little as 5% up to 100% Martian regolith, a black powdery substance meant to mimic the rocky, inorganic material found on the surface of the red planet.

While the parts with 5% Martian regolith were strong, the 100% regolith parts proved brittle and cracked easily. Still, even high-Martian content materials would be useful in making coatings to protect equipment from rust or radiation damage, said Amit Bandyopadhyay, corresponding author on the study published in the International Journal of Applied Ceramic Technology.

"In space, 3D printing is something that has to happen if we want to think of a manned mission because we really cannot carry everything from here," said Bandyopadhyay, a professor in WSU's School of Mechanical and Materials Engineering. "And if we forgot something, we cannot come back to get it."

Bringing materials into space can be extremely expensive. For instance, the authors noted it costs about $54,000 for the NASA space shuttle to put just one kilogram of payload (about 2.2 pounds) into Earth orbit. Anything that can be made in space, or on planet, would save weight and money — not to mention if something breaks, astronauts would need a way to repair it on site.

Bandyopadhyay first demonstrated the feasibility of this idea in 2011 when his team used 3D-printing to manufacture parts from lunar regolith, simulated crushed moon rock, for NASA. Since then, space agencies have embraced the technology, and International Space Station has its own 3D-printers to manufacture needed materials on site and for experiments.

For this study, Bandyopadhyay along with graduate students Ali Afrouzian and Kellen Traxel, used a powder-based 3D printer to mix the simulated Martian rock dust with a titanium alloy, a metal often used in space exploration for its strength and heat-resistant properties. As part of the process, a high-powered laser heated the materials to over 2,000 degrees Celsius (3,632 F). Then, the melted mix of Martian regolith-ceramic and metal material flowed onto a moving platform that allowed the researchers to create different sizes and shapes. After the material cooled down, the researchers tested it for strength and durability.

The ceramic material made from 100% Martian rock dust cracked as it cooled, but as Bandyopadhyay pointed out it could still make good coatings for radiation shields as cracks do not matter in that context. But just a little Martian dust, the mixture with 5% regolith, not only did not crack or bubble but also exhibited better properties than the titanium alloy alone, which meant it could be used to make lighter weight pieces that could still bear heavy loads.

"It gives you a better, higher strength and hardness material, so that can perform significantly better in some applications," he said.

This study is just a start, Bandyopadhyay said, and future research may yield better composites using different metals or 3D-printing techniques.

"This establishes that it is possible, and maybe we should think in this direction because it's not just making plastic parts which are weak but metal-ceramic composite parts which are strong and can be used for any kind of structural parts," he said.

UVA RESEARCHERS 3D-PRINT SOIL STRUCTURES THAT CAN GROW PLANTS

University of Virginia researchers have invented a method of 3D printing with seed-impregnated soil, which could be used to create walls and roofs teeming with plant life.

Someday, maybe sooner than later, people building homes and offices may be able to 3D-print their roofs and walls using soil implanted with seeds – think oversized Chia pets – thanks to new sustainability research at the University of Virginia.

You've probably seen buildings with roof-top gardens and terraces that support trees and grasses. It's cumbersome for architects and builders to graft soil and plants onto steel and cement, although the environmental payoffs can be big: gardens are natural insulators, soak up rain and provide green spaces for people, animals and pollinators.

Ji Ma, an assistant professor of materials science and engineering at UVA's School of Engineering and Applied Science, wondered: "Why do we have to make it so that the structure or building is separate from the nature it sits in?"

To answer this question, Ma forged a partnership with David Carr, a research professor in UVA's Department of Environmental Sciences, and Ehsan Baharlou, an assistant professor in UVA's School of Architecture. He also enlisted one of his students, Spencer Barnes, who joined Ma's research group as a first-year undergraduate and earned his Bachelor of Science in aerospace engineering in May 2022.

Together, they have proven that 3D-printing geometrically complex structures made of soil and seed is doable — introducing a key innovation in bio-based construction.

3D printing, or additive manufacturing, in architectural design and building construction is an emerging market, driven by community interest in green buildings and a need for affordable housing. Project Virginia exemplifies this trend. Alquist 3D, a builder of 3D-printed homes, launched Project Virginia to offer affordable and sustainable homes to people living in remote and underserved regions of the United States. The company broke ground on the project in Pulaski, Virginia, in late April, with plans to complete 200 homes in Pulaski and Roanoke by 2027.

The UVA research team is taking 3D-printing one step further, to combine additive manufacturing's speed, cost efficiency and low energy demands with locally resourced, bio-based materials. This design philosophy and approach aligns with a sustainable development practice called the circular economy.

As explained by the Ellen MacArthur Foundation, a circular economy delivers better outcomes for people and the environment by eliminating waste and

pollution, circulating products and materials at their highest value and regenerating nature. In our current economy, we take materials from the Earth, make products from them, and eventually throw them away as waste – the process is linear. In a circular economy, by contrast, we stop waste being produced in the first place.

"We moved to soil-based 'inks' to derive additional benefits from circular additive manufacturing," Baharlou said. "We are working with local soils and plants mixed with water; the only electricity we need is to move the material and run a pump during printing. If we don't need a printed piece or if it isn't the right quality, we can recycle and re-use the material in the next batch of inks."

Circular bio-based construction relies on more efficient use of raw materials in construction, in turn helping to reduce carbon emissions during the life cycle of a building. Not only are most components and materials used in the construction industry not adaptable, reusable or recycled during or after their lifecycle, they are often not locally sourced. Breaking away from the current linear approach to designing and constructing buildings to a circular one requires research and prototyping across architecture, engineering and construction.

That's where Barnes entered the picture.

"They paid me to play with dirt," Barnes said.

"Professor Ma has a very sophisticated additive manufacturing lab, working mostly with laser printing with metal powders. The printers are high-end, very precise and shiny. Then there's me at the corner table mixing up some soil concoction."

Barnes conducted experiments with soil-based inks, supported by a University of Virginia Harrison Grant. Using a desk-sized 3D-printer, he explored two approaches, printing soil and seed in sequential layers and mixing seed and soil before printing. Both approaches worked. Barnes produced a cylindrical prototype, about the size of soda can, which looked a bit like a Chia pet.

Baharlou then proposed 3D-printing soil structures with more complex geometries, such as domes. The research team, including Leah Kirssin, who earned a Bachelor of Science in architecture in 2021, and Lizzie Needham, who graduated with a Master of Landscape Architecture in the same year, tested how material comes out of the printer head or nozzle, a process called extrusion, without any additives to the soil mixture. These collective efforts revealed that 3D-printed soil structures can support plant growth but would likely be limited to plants that can survive with little water.

"3D-printed soil tends to lose water more quickly and keeps a stronger grip on the water it has," Ma said. "Because 3D printing makes the environment around the plant drier, we have to incorporate plants that like drier climates. The reason we think this is the case is because the soil gets compacted. When the soil is squeezed through the nozzle, air bubbles are pushed out. When the soil loses air bubbles, it holds onto water more tightly."

When a plant wants water, it has to fight the soil for it, exerting some pressure to lure the water from the soil and into the roots. At the same time, the soil exerts pressure of its own to retain water, referred to as matric potential. Whether the plant or the soil wins this tug-of-war depends on the type of soil, the variety of plant and the plant's maturity. To determine which plants can be grown in 3D-printed soil, Barnes explored the relative availability of water held in a soil over time, in combination with the amount of energy plants needed to extract the water.

To find the right mix of soil and seed, Ma reached out to Carr, who serves as director of Blandy Experimental Farm, an environmental science field station in Clarke County, Virginia.

"Some of my students have used 3D printing to make devices to collect pollen off of bees as they enter their

hives, but I never imagined that you could potentially print something that was biologically alive," Carr said.

Carr provided early advice on a range of soil properties. In addition to holding water, the soil needs to accumulate organic material and store nutrients. It also needs to allow the plants to get a root hold on the printed structure, so that once they get of any size they don't disappear or get washed off, or desiccate and die.
Carr proposed plants that naturally occur in areas where life is at its limits — native plants that grow practically right on bare rock. "Green roofs tend toward these species that are good at living under these really harsh conditions, getting baked in the sun," Carr said. "From this research, we can learn a lot about what works for green roofs to help with rain water, cooling and providing a habitat for pollinators and other insects."

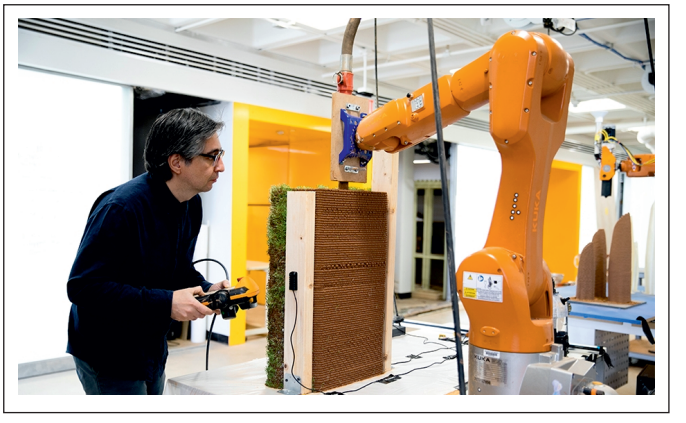
Carr recommended stonecrop as a good candidate for 3D-printing soil structures. Stonecrop, formally known as genus sedum, is commonly used in green roof settings. Stonecrop's physiology is similar to the cactus. It can survive on very little water, dry out and desiccate to some degree, and then recover.

The team published its results, 3D Printing of Ecologically Active Soil Structures, in the journal Additive Manufacturing earlier this year. Barnes, who first-authored the team's paper, will continue to help solve big problems with big impacts as a graduate student in mechanical engineering at Stanford University, where he plans to focus on hypersonic flight and propulsion research.

"I greatly enjoyed working with Dr. Ma and the rest of the team," Barnes said. "The combination of experts from different disciplines culminated in a unique project with big potential impact. I hope to continue working with similar interdisciplinary teams as I head to graduate school."

Ma, Baharlou and Carr have since expanded their research in 3D-printed soil structures, taking advantage of two 3Cavaliers program grants. UVA's Office of the Vice President for Research established and manages the 3Cavaliers grant program to help faculty from different schools work together.

Ma and Baharlou previously partnered with Osman Ozbulut, an associate professor of civil engineering and principal investigator on a 3Cavliers grant to develop a 3D-printing technique for Cement-Based Architectural Structures.



Supported by the School of Architecture's Fabrication Lab, or FabLab, Baharlou used this 3Cavaliers grant to establish an additive manufacturing fabrication system to 3D-print large structures. The centerpiece of the fabrication system is an industrial robot with a 3- to 4-foot reach that can deposit materials customized to an architect's desired objectives for a structure, such as space, function and geometry. Baharlou modified this system to create a printer that combined an extruder with an industrial robotic arm to conduct the soil structure experiments.

More recently, Ma and Baharlou earned a 3Cavaliers grant with Tomonari Furukawa, UVA professor of mechanical and aerospace engineering, to pursue research in Ecological Construction. They envision installing Baharlou's 3D-printing system on a moving robot. A mobile platform could enable 3D-printing multi-sided, complex structures such as a serpentine wall. Baharlou and Ma are also conducting experiments with other biodegradable materials including hemp.

"The team at the Office of the Vice President for Research has been instrumental in spurring

collaboration between architects and engineers," Baharlou said. "Our collaborative projects do more than demonstrate how to use local materials and provide improved quality of construction for buildings manufactured at a very fast pace. Our cross-discipline integration is helpful for society and humanity by advancing the applications of bio-based materials."

A benefit of the 3Cavaliers grants is the demonstration effect, enabling researchers to collect data and build prototypes to garner awards from major funding agencies such as the National Science Foundation. Ma, Baharlou and Carr are optimistic about pursuing this research agenda. Next steps including formulating soil inks for a larger structure, perhaps one story tall, anticipating that this larger dimension will exacerbate problems such as soil cracking. They are also experimenting with multiple materials layered within a wall panel to insulate the inner wall and maintain moisture for the outer wall.

"Regardless of the material – plastic, metal, clay, soil or plant life – in the end it's a materials problem," Ma said. "The additive manufacturing process creates uncertainties and opportunities within the material system you're working with that's different from conventional systems. You can approach this in different ways. You can try to avoid it and be afraid of it. Or you can try to control it and take advantage. That's the long-term goal of our research program."

X-rays, AI and 3D printing bring a lost Van Gogh art to life

PhD researchers Anthony Bourached (UCL Queen Square Institute of Neurology) and George Cann (UCL Space and Climate Physics), working with artist Jesper Eriksson, used cutting edge technology to recreate a long-concealed Van Gogh painting. It's the latest in their "NeoMasters" series of recreations, a project they've been working on since 2019 to bring lost works of art to life. They developed a process to recreate lost works that uses x-ray imaging to see through every layer of paint, AI to extrapolate the artist's style, and 3D printing to fabricate the final piece. This newest effort, dubbed

Using X-rays, artificial intelligence and 3D printing, two UCL researchers reproduced a "lost" work of art by renowned Dutch painter Vincent Van Gogh, 135 years after he painted over it.

"The Two Wrestlers," depicts two shirtless wrestlers grappling in front of an abstract background. It recreates a painting originally by Van Gogh who covered over the two figures when he reused the canvas for an unrelated painting of flowers.

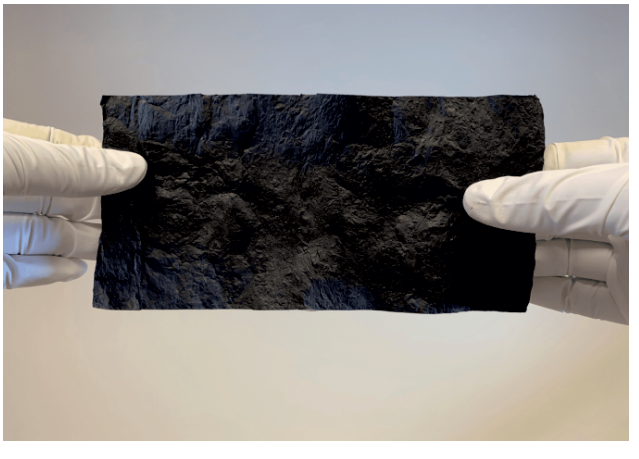
Commenting Bourached, who is researching Machine Learning and Behavioural Neuroscience at UCL, said: "How much it is like the original painting is impossible to tell at this point because the information doesn't exist. I think it's very convincing – by far the best guess we can get with current technology."

The obscured image was first discovered in 2012 when art experts at the University of Antwerp investigated whether the work "Still Life with Meadow Flowers and Roses" was an authentic Van Gogh. The researchers examining the artwork used X-rays to peer through the layers of paint and discovered two ghostly figures that had been painted over. The covered-over wrestlers displayed brush strokes and pigments that were consistent with Van Gogh, and the subject matter was also a common theme at the Antwerp Art Academy where Van Gogh was studying in 1886, authenticating the work.

"This week I painted a large thing with two nude torsos — two wrestlers... and I really like doing that," Van Gogh wrote in a letter to his brother Theo in January of 1886. Bourached and Cann developed a series of algorithms that identified the edges and created an outline of the figures from the X-ray data. They then used a neural network that learned from hundreds of other Van Gogh works to predict the style of colours, details and brushstrokes of the painting. Finally, the team used a 3D printer to construct the final art piece. Using similar image analysis and fabrication techniques, the team was able to resurrect other images that had been considered lost for many years. In 2021, the team first recreated a painted-over image of a crouching nude woman beneath the painting "The Blind Man's Meal" by Pablo Picasso.

"The Two Wrestlers" is being displayed at the Louvre in Paris from 1 to 4 September at the FOCUS Art Fair, alongside three other NeoMasters works, including ones recreating works by Leonardo Da Vinci and Amedeo Modigliani. The exhibition is being put on in conjunction with the MORF Gallery in California and the researcher's company Oxia Palus.

Illinois researchers developed a method to 3D print carbon nanotubes



Researchers in the Lyding Group at the University of Illinois Urbana-Champaign discovered an efficient, sustainable method for 3D-printing single-walled carbon nanotube films, or thin aggregated sheets of carbon nanotubes that are adaptive enough to outfit an aircraft or contour to the human body.

The unsung hero of space exploration, aerospace engineering, and wearable electronics is manufacturable with powder, ink, and a novel 3D printing process. The unsung hero of materials science can clean up chemical spills and weather the temperature swings of outer space. It's adaptive enough to outfit an aircraft or contour to the human body. And, at the University of Illinois Urbana-Champaign, it's manufacturable with powder, ink, and 3D printing. Researchers in the Lyding Group discovered an efficient, sustainable method for 3D-printing single-walled carbon nanotube films, a versatile, durable material that can transform how we explore space, engineer aircraft, and wear electronic technology.

Made of carbon-based tubes with diameters between 1 and 2 nanometers wide, this small-but-mighty material has been scrutinized by researchers for decades. Gang Wang, the study's lead author, discovered a novel way to produce them.

Gang Wang, a former Beckman Institute researcher, is a lead coauthor on a study that discovered a novel method for 3D-printing carbon nanotube films, a versatile, durable material with the potential to transform how we explore space, engineer aircraft, and wear electronic technology.

"We were inspired by the idea of creating a material that is lightweight, but strong and conductive like metals," said Wang, a former researcher at the Beckman Institute for Advanced Science and Technology. "After many attempts, we chose a printing method based on a 3D printer, which produces the film with outstanding properties and high efficiency."

His method, which is reported in Nano-Micro Letters, is easily scalable and environmentally friendly. Forgoing polymers in favor of a simpler recipe consisting of carbon powder, ink, and a 3D printer enables the team to create carbon nanotube films that are stronger and more durable than existing versions of the material.

"We're seeing properties from these carbon nanotubes that are really incredible, said Joseph Lyding, a

professor of electrical and computer engineering who has studied and published about the material for years.

Researchers in the Lyding Group at the University of Illinois Urbana-Champaign discovered an efficient, sustainable method for 3D-printing single-walled carbon nanotube films, or thin aggregated sheets of carbon nanotubes that are adaptive enough to outfit an aircraft or contour to the human body.

Despite weighing only one-fifteenth of what copper weighs, carbon nanotubes are more thermally conductive than their metal counterpart. This helps the materials weather extreme temperature swings not unlike those experienced in space.

"Spacecraft could certainly benefit from the addition of carbon nanotubes. In space, materials are subjected to extreme temperature changes depending on whether they are facing the sun or the cold of deep space. Our films could easily withstand these changes," Lyding said.

Lying on their sides like logs rolling down a nanoscale river, carbon nanotubes aggregate in large quantities to form films that are centimeters to meters in size, the researchers said.

"Think of the carbon film like a piece of cloth, and the carbon nanotubes are the individual threads in the cloth. The only difference is that we can see the individual threads in our clothing with the naked eye," Lyding said.

Though approximately 100,000 times narrower than a cloth thread, carbon nanotubes share a function with wool, cotton, and felt — the material's mechanical flexibility is an ideal characteristic of wearable electronics, refusing to break even after experiencing "deformations like bending, twisting, and kneading," Wang said.

Joseph Lyding, a professor of electrical and computer engineering at the University of Illinois Urbana-Champaign and a researcher at the Beckman Institute, led a study that discovered an efficient, scalable 3D-printing method for producing single-walled carbon nanotubes.

The films have just as many uses within Earth's atmosphere as without. Their mechanical flexibility, for example, makes them ideal for vehicles in the air and on land that sustain high levels of jostling and vibration — for example, a rocket launch or moving aircraft. And they're handy in a crisis:

"Their chemical durability may be useful for prolonging device lifetime or for use in equipment subject to extreme chemical conditions such as inside of chemical reaction vessels or in equipment used for chemical spill cleanup," Lyding said.

A current researcher at the Beckman Institute, Lyding credits the success of the project to the institute's world-class facilities and collaborative environment.

"This is an example of something that has its origins in Beckman," he said of this study. "We used the Microscopy Suite extensively, [for] scanning electron and transmission electron microscopy. We set up the initial 3D printing process in one of the chemical labs in Beckman, and our lab at Beckman is still the home base for this project."

From the cosmos to the classroom

Given the straightforward method of creating the films with powder, ink, and 3D printing, an immediate application of the technology occurs not in the cosmos, but in a UIUC classroom.

Researchers in the Lyding Group at the University of Illinois Urbana-Champaign discovered an efficient, sustainable method for 3D-printing single-walled carbon nanotube films, a versatile, durable material with the potential to transform industries from wearable technology to aerospace engineering and space exploration.

In spring 2022, Lyding incorporated this process into an

undergraduate course he developed — Electrical and Computer Engineering 481: Nanotechnology — which contains a unique lab experience led by Dane Sievers that allows students to print their own carbon nanotube structures and measure physical properties like thermal and electrical conductivity.

"Students really like that, especially the hands-on lab. I always have and still do have undergraduate students involved in research," Lyding said. "It's an opportunity for students to get involved with something they probably weren't aware of. Their research is motivating. It brings out a potential some students did not know they had."
Brendan Wolan, a graduate student studying electrical and computer engineering and a coauthor on this publication, participated in ECE 481 as an undergraduate.

"[It] was my introduction to nanotechnology and was a turning point in my academic and professional career. There is a lot of excitement and energy in the field and this research is at a frontier. Since there are so many unknowns, ECE 481 prioritizes and rewards creativity in the lab.

"The lessons I learned during the class have been invaluable to me as I've continued my own research, much of which was born from questions first asked in the 481 classroom," Wolan said.

Safety and student participation are a priority in Lyding's lab, ensuring that whether the carbon nanotubes are positioned at the frontier of outer space or a lab space, opportunities for discovery are limitless.

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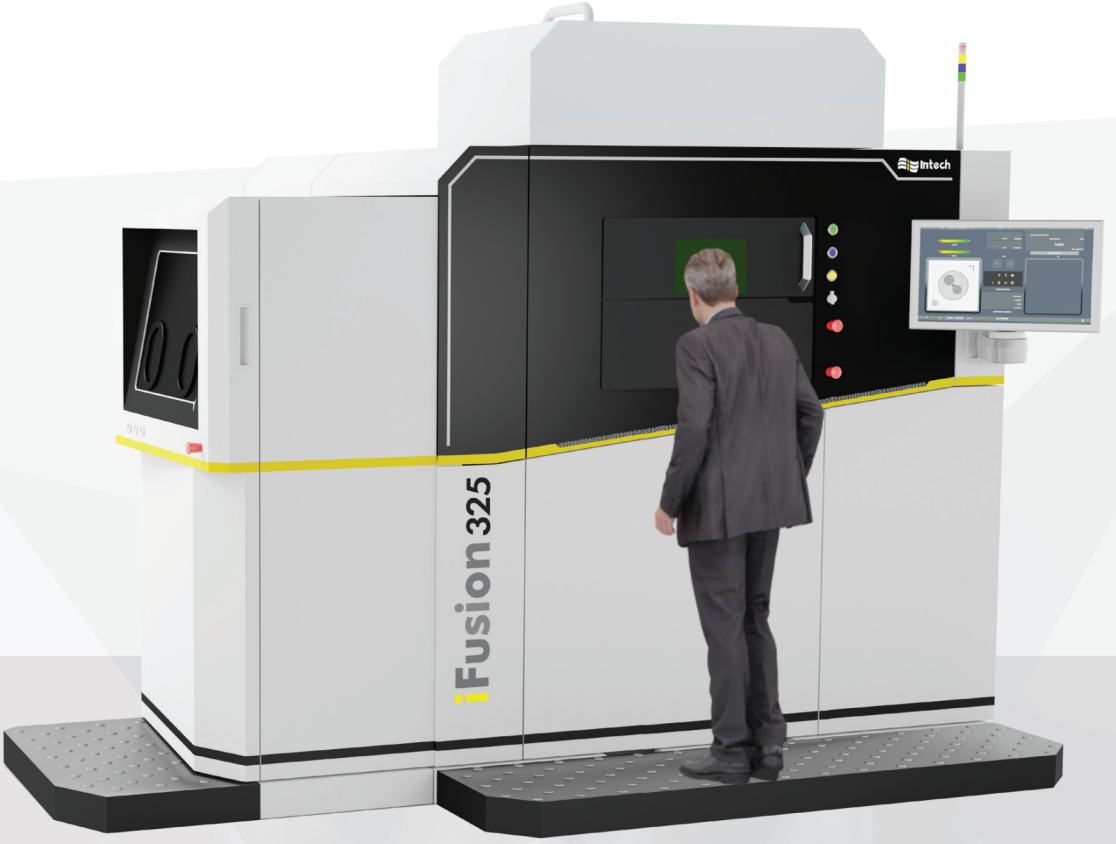

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