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FEATURE ARTICLE

The Growing Indian Additive Manufacturing Ecosystem: A Promising Frontier

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EDITORIAL

The evolving Additive Manufacturing landscape in India

In the recent era of technological advancements, India has appeared as a key region in the global additive manufacturing ecosystem. The growing adoption of additive manufacturing technologies across various industries is helping to support the manufacturing landscape in the country. From automotive to healthcare, the transformative potential of additive manufacturing is becoming increasingly apparent for various industries. AM Chronicle magazine's current issue is dedicated to the Indian additive manufacturing ecosystem.

AMTECH 2023 is one of the largest business networking platforms for Additive Manufacturing Technology in India and globally. AMTECH offers an opportunity to understand the additive manufacturing ecosystem. Attendees can explore world-class exhibits, participate in expert-led conferences, and network with industry leaders, providing a comprehensive experience to make informed decisions about integrating additive manufacturing into their industries. The event catalyzes collaboration knowledge exchange, and accelerating additive manufacturing adoption across diverse sectors. This year, AMTECH 2023 has an exclusive "German AM Zone," integrating the German and Indian ecosystems. In addition, AMTECH 2023 also has special zones focused on footwear, ceramics, and medical to introduce to the audience the latest trends in these sectors. To promote start-ups in additive manufacturing, AMTECH 2023 also has a start-up zone, which features the latest start-ups in these areas.

In the area of additive manufacturing news and updates, AM Chronicle has set up itself as a reliable online media platform. Dedicated to covering the latest developments, trends, and breakthroughs in additive manufacturing, AM Chronicle serves as a valuable resource for professionals, researchers, and enthusiasts. By supplying prompt and insightful content, the platform contributes to knowledge and creates a well-informed community enthusiastic about the future of manufacturing in India.

As we see the additive manufacturing ecosystem in India evolve, it becomes imperative for industry stakeholders, researchers, and enthusiasts to stay connected and informed. The combination of events like AMTECH 2023, MAMS, and AM CONCLAVE and platforms like AM Chronicle and Additive Academy helps to create a constructive collaboration, propelling the additive manufacturing landscape forward.

In conclusion, as we navigate the landscape of additive manufacturing in India, it is evident that the nation is propagating into a new era of manufacturing excellence. The journey is marked by events like AMTECH 2023 and platforms like AM Chronicle, which play roles in helping various stakeholders in the areas of additive manufacturing.

Aditya Chandavarkar
Co-Founder - AM Chronicle

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Vehicle Conformal Cooling Nozzles printed by HBD

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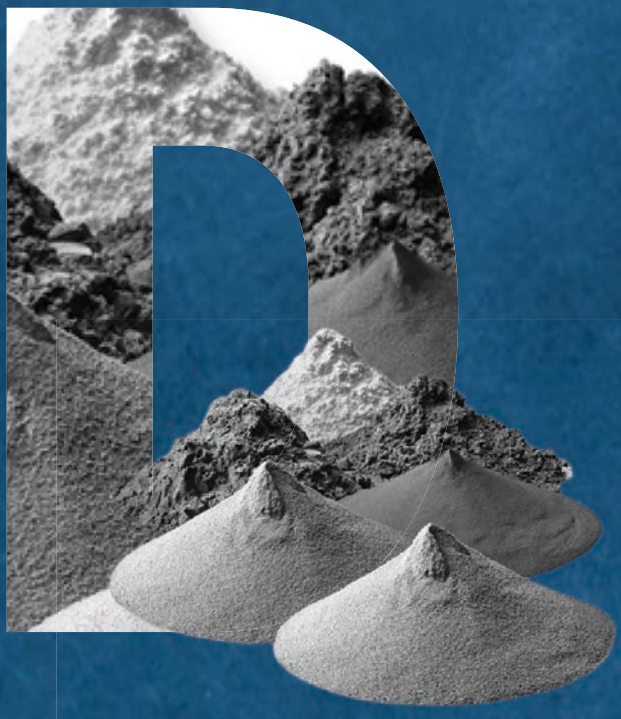

3D ADDITIVE MANUFACTURING

- METAL BINDER JETTING
- LASER POWDER BED FUSION

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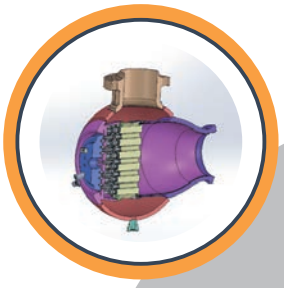

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The Growing Indian Additive Manufacturing Ecosystem: A Promising Frontier

Aditya Chandavarkar

Understanding the Growing Indian Additive Manufacturing Ecosystem

In recent years, India has witnessed a remarkable surge in the field of Additive Manufacturing (AM). The Indian additive manufacturing market is predicted to reach USD 1.79 Billion by 2030, with a CAGR of 28.1% (Source). This technology offers a host of advantages, from rapid prototyping to customization and reduced waste, when compared with traditional manufacturing. The Indian AM ecosystem is rapidly evolving, driven by a confluence of factors such as technological advancements, government initiatives, and a burgeoning interest from industries across the spectrum.

Technological Advancements

The core of the growing AM ecosystem in India lies in technological advancements. 3D printing technologies have matured, becoming more sophisticated and accessible throughout India. From stereolithography to selective laser sintering, the range of available

technologies has expanded, allowing for the creation of intricate and complex structures. This has not only broadened the scope of applications but has also enhanced the precision and efficiency of the manufacturing process.

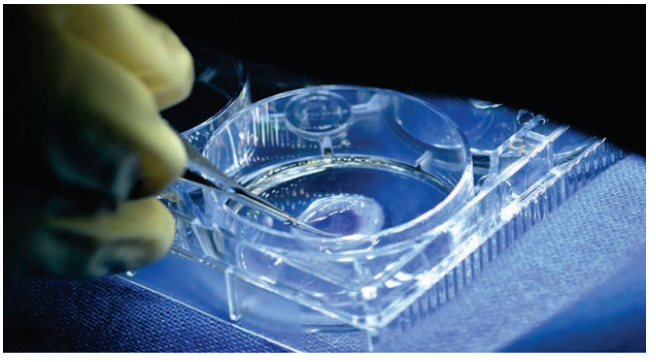


Figure 1: Research on 3D Printed Cornea in India

Indian researchers at IIT-H have successfully developed India's first 3D printed cornea and tested it on rabbit. It may take significant further investigation for human use, but the research shows promising future.

The research and development on additive manufacturing through Indian research institutes have also expanded. Institutes of national importance such as IITs, NITs , RRCAT, ISRO , BARC and others have shown significant process in R&D and developed new start-ups and technologies.

Government Initiatives

The Indian government has recognized the potential of additive manufacturing in driving economic growth and technological innovation. Initiatives such as the "Make in India" campaign and the National Strategy for Additive manufacturing have created a conducive environment for the growth of the AM ecosystem. The government's focus on research and development, skill development, and infrastructure improvement has played a pivotal role in fostering innovation and entrepreneurship in the field.

Moreover, financial incentives and subsidies for businesses adopting AM technologies have spurred the integration of 3D printing across various industries. The government's commitment to supporting startups and small and medium enterprises (SMEs) has provided the necessary impetus for these entities to explore and invest in additive manufacturing. Additionally, the government initiatives such as start-up Indian have resulted in development of Indian AM ecosystem.

The National Strategy for Additive Manufacturing is a strategy developed by the Government of India to encourage the development and adoption of additive manufacturing in the country. The strategy aims to increase India's share of the global AM market to 5% by 2025 by developing 50 India-specific technologies for material, machine, and software, creating 100 new startups for additive manufacturing, developing 500 new products, and training at least 1 lakh new skilled workers. The strategy also includes the establishment of an AM Innovation Centre, the development of a National AM Talent Pool, and the promotion of R&D.

Figure 2: 3D Printed Rocket Engine by Agnikul

Diverse Applications Across Industries

The applications of additive manufacturing are vast and varied, spanning across industries such as aerospace, automotive, healthcare, and consumer goods. In aerospace, for instance, 3D printing is being used to manufacture lightweight components, reducing fuel consumption and enhancing overall efficiency. The automotive sector has embraced AM for rapid prototyping, custom part production, and even the creation of electric vehicle components.

Rocket engines are difficult to build, and more so in 3D because everything has to be 'just right' for the rocket to operate effectively. But this mammoth mission was pulled off by an Indian space startup Agnikul operating out of Chennai.

The healthcare sector, in particular, has benefited significantly from these technological strides. Additive manufacturing has revolutionized the production of medical implants, prosthetics, and even personalized pharmaceuticals. The ability to tailor solutions to individual patient needs has opened new frontiers in healthcare, making treatments more effective and patient-specific.

Figure 3: 3D Printed Homes for Indian Army

The Indian Army inaugurated its first two-storey 3D Printed House Dwelling Unit for soldiers at Ahmedabad Cantt. This 3D-printed house is a disaster-resilient structure that complies with Zone-3 earthquake specifications and green building norms.

Even the consumer goods sector is experiencing a transformation with the advent of 3D printing. Customization of products, from fashion accessories to home decor, is becoming more prevalent, offering consumers unique and personalized items.

Challenges and Opportunities

One of the primary challenges facing the Indian AM ecosystem is the limited awareness and understanding of 3D printing technologies. Many businesses are yet to grasp the full potential and applications of AM, leading to hesitancy in adoption. Addressing this challenge requires comprehensive education and awareness campaigns to demystify the technology and showcase its capabilities.

Another hurdle is the lingering concerns about material quality and the post-processing requirements of 3D-printed objects. Ensuring the reliability and consistency of materials used in additive manufacturing processes is crucial for industries like aerospace and healthcare. Developing and standardizing high-quality materials, coupled with efficient post-processing techniques, is imperative to overcome this challenge.

The rapid expansion of the AM ecosystem has created a demand for skilled professionals in design, engineering, and material sciences. However, there is a shortage of a well-trained workforce to meet this demand. Bridging this skills gap requires concerted efforts from educational institutions, training centers, and industry players to develop specialized courses and training programs tailored to the needs of the additive manufacturing sector.

The initial investment and operational costs associated with additive manufacturing technologies can be prohibitive for some businesses, especially small and medium enterprises (SMEs). Government initiatives offering financial incentives and subsidies are a step in the right direction, but continued efforts are needed to make these technologies more accessible and affordable for a broader spectrum of industries.

The Indian government's proactive role in promoting advanced manufacturing, as exemplified by initiatives like "Make in India," presents a significant opportunity. Continued support in the form of research grants, subsidies, and policy frameworks can propel the AM ecosystem further. Collaboration between the public and private sectors can foster an environment conducive to innovation and growth.

Additive manufacturing's inherent capability for customization and personalization opens up new vistas across industries. From tailored medical implants to personalized consumer products, the ability to create unique items provides businesses with a competitive edge. Leveraging this opportunity requires a shift in mindset and the development of business models that capitalize on the value of customization.

The interconnected nature of the global economy presents an opportunity for the Indian AM ecosystem to collaborate with international counterparts. Joint research projects, knowledge exchange, and partnerships with global players can accelerate innovation and elevate the country's standing in the global additive manufacturing landscape.

The versatility of additive manufacturing allows for diverse applications across industries. From aerospace components to healthcare solutions and consumer goods, the scope for innovation is vast. Encouraging research and development in niche areas and fostering cross-industry collaborations can unlock new avenues for growth and application.

Conclusion

The Indian additive manufacturing ecosystem has a significant potential for growth and development. As the technology continues to evolve, the opportunities for diverse applications and industry collaborations are boundless. With government support, technological advancements, and a collaborative spirit, India is poised to become a significant player in the global additive manufacturing landscape. The journey from rapid prototyping to revolutionizing healthcare and beyond is an exciting trajectory, marking the ascent of India in the realm of additive manufacturing.

ABOUT THE AUTHOR

Aditya Chandavarkar

Managing Editor, 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.

INDO-MIM aims to advance 3D printing from metal powder to component manufacturing

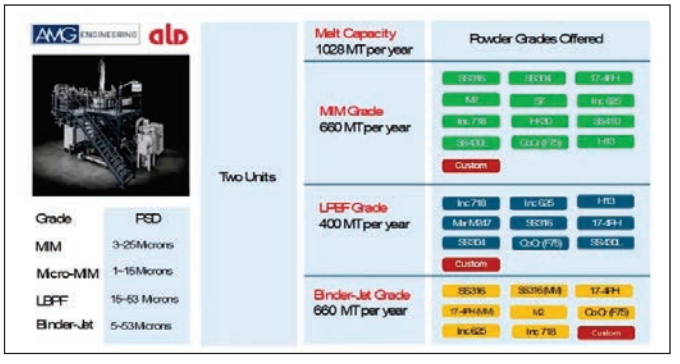
INDO-MIM

Metal Powders Production and Metal Additive Manufacturing at INDO-MIM

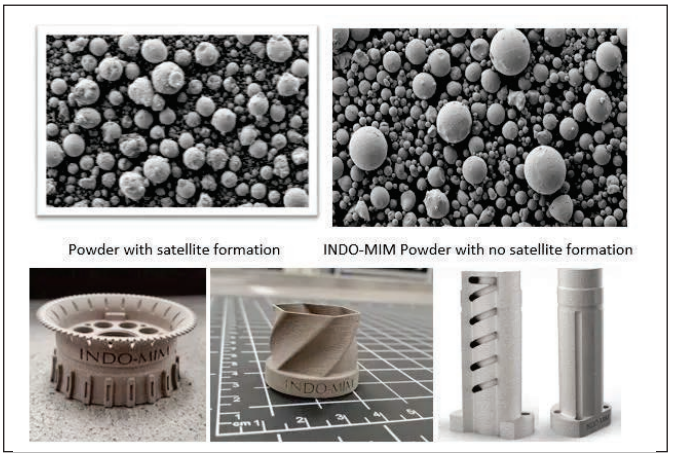
Backed by years of manufacturing expertise in metal injection molding, INDO-MIM aims to advance 3D printing from metal powder to component manufacturing.

One of the world's leading metal injection molding manufacturer, INDO-MIM, has branched out into production of spherical gas atomized powders and as well as contract manufacturing of metal components utilising Additive manufacturing (AM). Having a world class powder manufacturing facility in Bengaluru, India, INDO-MIM has established a melt capacity of ~1100 tons/annum producing highly spherical powders for Metal injection molding (MIM), Laser powder bed fusion (LPBF) and Binder jet metal printing (BJT) technologies. Wide range of metal powders with particle size

distribution ranging from 5-150 µm are being produced for broader range of AM applications. Material portfolios includes Stainless steels, Tool steels, ferrous, Nickel and Cobalt based super alloys. Powders with custom particle size distribution (PSD) and/or chemistry can be door delivered at the competitive price and shortest lead time.



INDO-MIM's speciality engineered powders with optimum particle size distribution (PSD), and flowability enable printing components with highest print quality eliminating unwarranted secondary finishing operations post sintering. Thanks to proprietary anti-satellite system ensuring powder with no satellite formation resulting in high quality printed components. Having a fleet of Laser Bed Fusion (LBF) and Binder jet production 3D printers both in India and as well as in U.S, INDO-MIM has been a widely known contract manufacturing firm providing one stop solution to customers in delivering highly complex precision metal



components. We have so far produced 200,000+ components in our AM operations for customers in medical, industrial, defence, aerospace and consumer goods market.

The facility is equipped with wide range of secondary finishing operations including CNC finishing along with world class quality assurance equipment. Indo MIM's investment in AM demonstrates our technical capabilities in adaptation of newer manufacturing technologies on a production scale with the implementation of digital manufacturing in the shop floor. We remain confident of producing high quality metal AM components with competitive cost, material flexibility with the advantage of in-house powder production. You may reach out following for more information on your metal powder requirement and AM capabilities.

ABOUT THE AUTHOR

INDO-MIM Private Limited

From a humble beginning in 1996, INDO-MIM has grown to become a leading global supplier of Metal Injection Molded (MIM) products. INDO-MIM has achieved a leadership position in the field of MIM, providing precision-engineered products to customers in more than 45 countries in the Americas, Europe, and Asia. INDO-MIM is a fully integrated MIM parts producer with capabilities and proficiency in design, tooling, materials, and a full range of finishing and assembly operations. We are the world's largest MIM company, with a well-established facility in Bangalore, India & Texas, USA. We have developed 6000+ varieties of MIM parts/components for various segments Like Defense, Automotive, Consumer, Medical, Aero and catering to more than 45 countries globally.

The Advantages of Resin 3D Printing and Why It Might Make Sense for You

Param Mehta

The article explores the key advantages of Resin 3D Printing over Fused Deposition Modeling

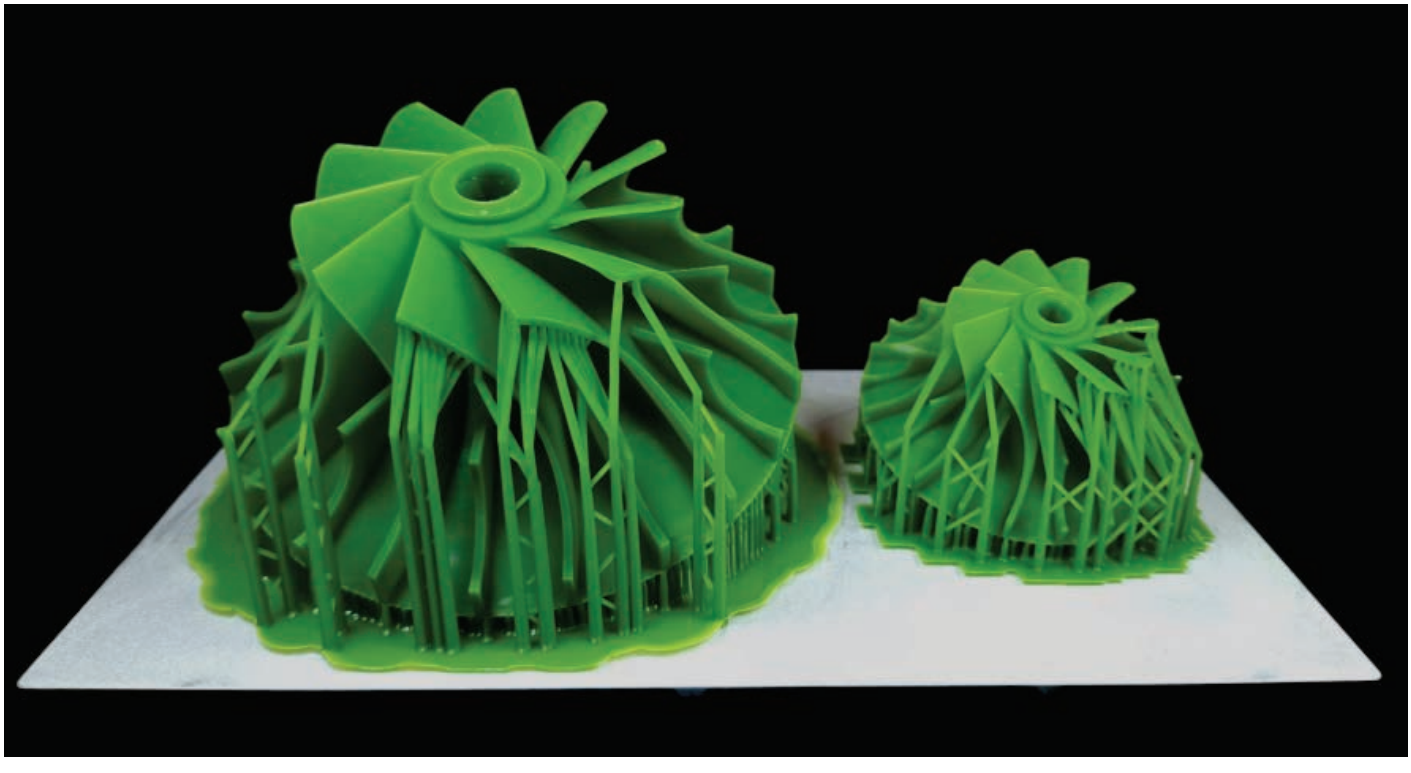


Photo Credits: FORM3D

When it comes to selecting the right 3D printer for your application, the conventional wisdom suggests FDM for affordability, SLA/DLP for precision, and SLS for large-scale industrial use. However, these generalisations often fall short in capturing the full picture.

Cost

Traditionally, FDM printing has been the go-to for cost-effective parts and prototypes. On the face of it, this makes sense because of typical material costs- PLA filament can cost in the neighbourhood of Rs.1000/kg while Nylon Powder (SLS) and Resin (SLA/DLP) is typically thought to cost significantly more. While this was the case a few years ago, especially with resins available from OEMs that locked you into their ecosystem (legacy company resins still cost over Rs. 8000/kg and go up to Rs. 50000/kg for their speciality

resins), now there are resins available under Rs. 2000/kg such as FORM3D's clear resin that is developed and manufactured in India.

Moreover, the cost of resin based MSLA printers has dropped in recent years with a medium to large capacity, extremely high resolution MSLA printer costing anywhere between Rs. 30000-50000.

Finally when looking at the final cost of 3D prints (material cost + time on the printer), certain prints that come out of resin printers often tend to be the most economical due to-

Speed

Modern MSLA/DLP resin printers typically print parts much faster than any other printer because they cure entire layers in a few seconds. Here's an example-

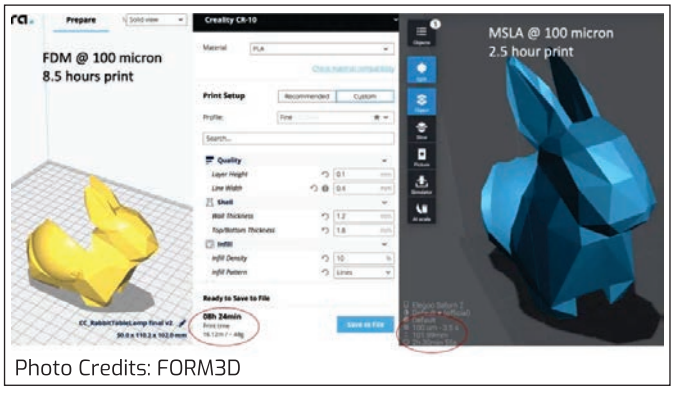


Photo Credits: FORM3D

If we price for time and material used in costing (but don't include the extra time for finishing (see below)), the FDM part would cost Rs. 150 while the MSLA part would cost Rs. 110.

Economies of scale

If a batch of parts are needed to be printed, and they all fit on the build platform together, the time required to print these parts using resin printers is the same as the time required to print a single part. This is the case for SLS parts but not for FDM parts. Here's an example-

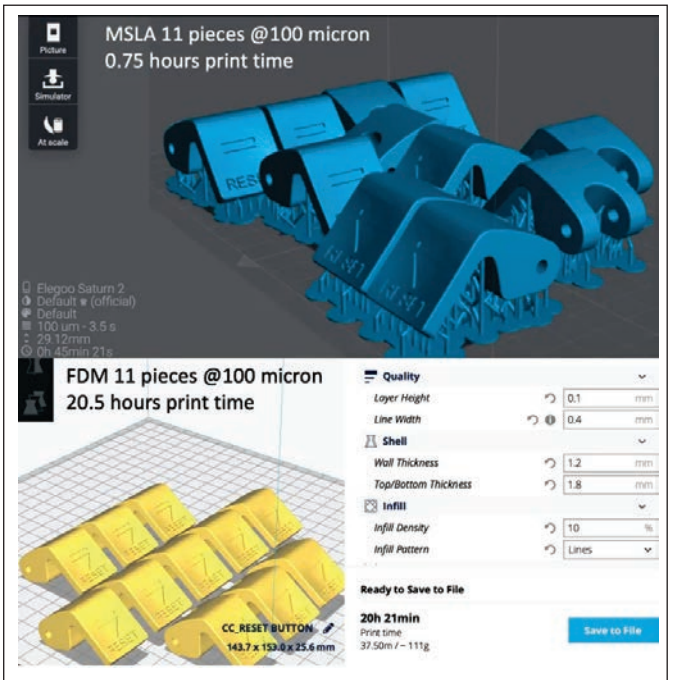


Photo Credits: FORM3D

Again, if we price for time and material used in costing (but don't include the extra time for finishing (see below)), the FDM parts would cost Rs. 340 while the MSLA parts would cost Rs. 230 (in addition to being ready over 18 hours earlier!).

Finishing

Resin parts require the least amount of finishing- simply post cure parts in the UV chamber for a minute and remove supports to get completely smooth non porous parts. Due to the high accuracy, sanding and smoothening is not required unlike in FDM and SLS parts. For additional finishing, regular acrylic paints stick better directly to resin parts than to filament or powder based parts which need primers as a base coat.
Part properties

Resin parts used to be thought of as weak and brittle but several new resins are available like FORM3D's Snap-F which is strong and slightly flexible making it perfect for certain engineering applications, or FORM3D's High Temp which has a Shore D hardness of over 90 and can easily withstand temperatures over 200℃ (a temperature most thermoplastics used in FDM and SLS printing cannot withstand).

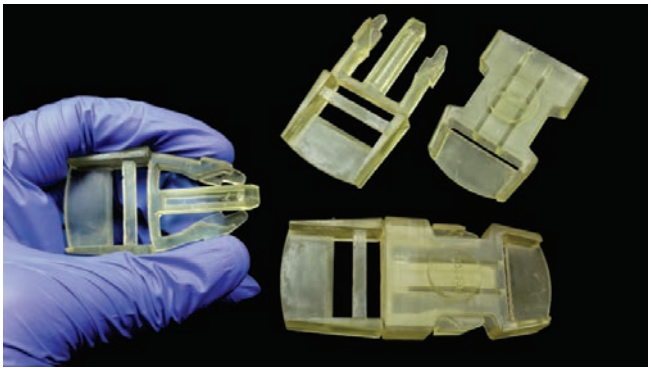


Photo Credits: FORM3D

Additionally in certain applications, resin 3D printing has already taken over as the most cost effective and best method of producing final parts especially due to the high level of accuracy and design freedom it provides as well as the growing library of resins available.

The jewellery industry has almost completely switched from creating manual designs into using CAD/CAM using resin based 3D printers to create perfect master parts that have extremely high levels of part features and accuracy. These are then silicone moulded and cast in wax in multiple numbers for investment casting. Increasingly, jewellery manufacturers are now using castable resins like FORM3D's Jewellery Casting to skip the step of creating a silicone mould and wax casts, and instead are simply putting the 3D printed resin models into the investment, and burning them off (without any carbon deposits). When producing under 500 pieces of the same pattern and size, this tends to be a more economical solution for manufacturers.

Similarly in the dental industry, all over the world, crowns and bridges are now being made predominantly by 3D printing them in casting resins like FORM3D's Dental Casting, and investment casting them in metals or ceramics that are safe to implant in patient's mouths.

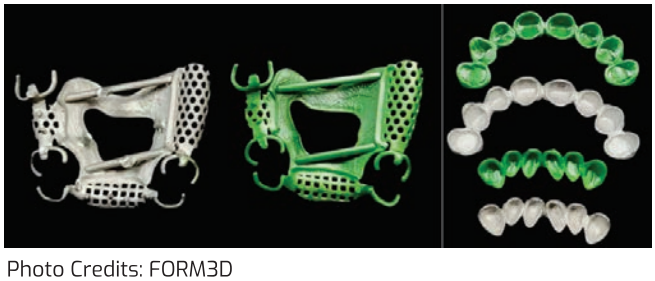


Photo Credits: FORM3D

New resins are also being developed and sold that are biocompatible and have mechanical properties similar to natural teeth allowing dentists to 3D print crowns which directly can be implanted into their patients' mouths.

Photo Credits: FORM3D

Healthcare and in particular implants are a major future market for biocompatible resin 3D printing because of the requirement for individualisation, extremely high accuracy, and a quick production time.

Medium scale manufacturing

Higher performance resins allow for medium scale manufacturing of functional parts- not simply non functional prototypes as is generally the case for most 3D printed parts.Resins are available that mimic or even exceed properties of commonly used thermoplastics like ABS, PET, HDPE etc. FORM3D's range of F resins achieve and surpass some of these properties.

Injection moulding proves economical only for quantities exceeding 10,000 units, largely due to expensive tooling. Tooling also takes time- sometimes multiple months before the parts can be manufactured. Due to this, manufacturers often commit to manufacturing a higher number of parts than they actually need, and then storing them in warehouses (which also leads to higher storage and transportation costs). Additionally, manufacturing parts in higher numbers can lead to slower update

cycles of products because sales teams are incentivised to sell off old stock before launching newer versions out of fear of obsolescence.

3D printing in resin can solve some of these problems. Due to the economies of scale available (specifically related to time of production), manufacturers can set up print farms which manufacture much smaller batches (10-500) of parts at different locations which could significantly reduce warehousing and transportation costs.

See the above reset buttons image as an example. Depending on the build platform of the resin 3D printer, 1000 parts could be manufactured in 50 hours of print time at a cost of Rs. 16 per piece. Even 10000 parts on resin 3D printing would take 24 days as opposed to having to wait 2-3 months just for the tooling to be completed.

Another way to reduce batch sizes is to 3D print the core of injection moulding tools using high temperature resins like FORM3D's High Temp which allows approximately 100 shots of plastic. These cores can either be reprinted for more parts, or the design can be changed allowing for a lot more design flexibility. 3D printed cores can also be used as tooling prototypes to eliminate potential mistakes in metal tooling design which is often unfixable and leads to delays of several months.

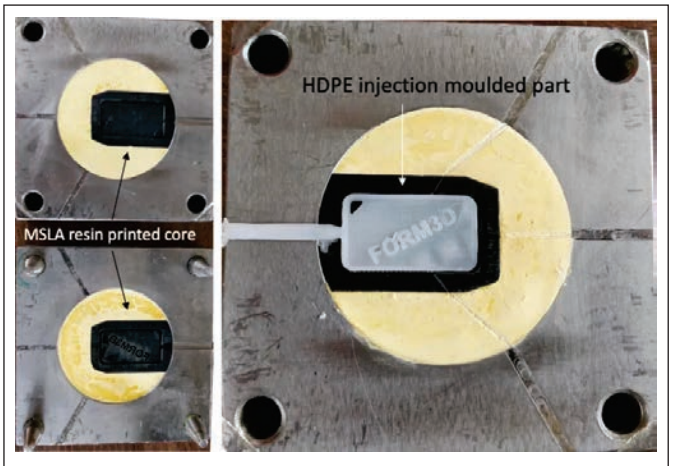


Photo Credits: FORM3D

If you have questions about which type of 3D printing makes the most sense for your organisation, get in touch with experts like FORM3D's support team who will be able to guide you at support@form3dresin.com

ABOUT THE AUTHOR

Param Mehta

Mr. Param Mehta is the founder and director of FORM3D Chemicals Pvt Ltd- one of the only 3D printing resin manufacturers in India. He has worked in the 3D printing space in India for over 8 years and his passion lies in exploring the transformative potential of this technology and its manifold advantages for businesses.

Understanding the 3D-Printed Footwear revolution

Chinmay Saraf

Explore the various facts of how 3D printing is transforming the world of footwear

Adidas 3D Printed Running Shoes, Source: Adidas

The world of footwear is changing rapidly, and 3D printing has been identified as a key technology that will play a significant role in its future. From customization to sustainability, new applications of 3D-Printed Footwear are being explored by leading footwear companies and start-ups globally.

In this insight article by AM Chronicle, we explore the various facts of how 3D printing is transforming the world of footwear, from consumer adoption and market trends to medical applications and the exciting future of 3D-printed shoes.

Consumer Adoption and Market Trends

Consumer preferences and market trends are key

drivers in the footwear industry. The Global 3D Printed Footwear Market is valued at USD 993.22 Million in 2022 and is projected to reach a value of USD 3758.75 Million by 2030 (Source). North America is expected to be the largest regional market for 3D printed footwear, followed by Europe and Asia Pacific. In recent years around 15% of the U.S. youth population prefer 3D Printed Footwear Market for better lifestyle and comfort. Major players such as Adidas and Nike are investing heavily in the research and development of 3D Printed Footwear Market. The most comment technique used in developing these footwear is AM hardware units and in 2025 this technology is expected to generate revenue up to USD 5,500 million (Source).

Customization and Personalization through 3D Printing in Footwear

With 3D printing, consumers can create shoes that are perfectly tailored to their individual needs and preferences, taking into account their unique foot shapes, gaits, and style preferences. 3D printed shoes can be made to fit a person's feet exactly, eliminating the common problems of ill-fitting shoes, such as blisters, pain, and poor performance. It also allows for the creation of shoes with specific performance characteristics, such as improved cushioning, support, and flexibility. Additionally, empowers consumers to express their individuality by creating shoes with unique designs, colors, and patterns.

The starting point for creating custom 3D printed shoes is to scan the individual's feet using a 3D scanner. This creates a precise digital model of the feet, capturing their unique shape and contours. The 3D scan data is then used to create a 3D model of the shoe. This model can be customized in various ways, such as adjusting the fit, adding arch support, or incorporating unique design elements. Once the 3D model is finalized, it is sent to a 3D printer, which builds the shoe layer by layer using a variety of materials, such as plastic, nylon, or TPU (thermoplastic polyurethane).

Sustainable Footwear Manufacturing Using 3D Printing Technology

Sustainable footwear manufacturing is a growing trend in the footwear industry, as companies and consumers alike become more aware of the environmental impact of footwear production. One of the most promising technologies for sustainable footwear manufacturing is 3D printing.

In the 3D printing process products are built up layer by layer, rather than being cut from a solid block of material. This reduces waste significantly, as there are no scraps or offcuts. 3D printing is more energy-efficient than traditional manufacturing processes, such as injection molding. This is because 3D printers only heat up the material that is being printed, rather than heating the entire mold. 3D printing allows for on-demand production of footwear. This means that shoes can be printed as needed, rather than being produced in large batches and then stored in warehouses. This reduces inventory waste and transportation emissions. Additionally, it can be used to print footwear from a variety of sustainable materials, such as recycled plastics, bio-based materials, and even algae.

Zellerfeld is a German footwear company that produces custom-made 3D printed shoes from

Zellerfeld 3D Printed Shoes, Source: Zellerfeld

recycled materials. Zellerfeld's shoes are made to order, which reduces inventory waste. The company also offers a recycling program for its shoes, so that customers can return their old shoes to be recycled into new ones.

Hilos is a Spanish company that produces 3D printed shoe soles from recycled materials. Hilos' soles are designed to be lightweight and durable, and they can be recycled at the end of their life. Hilos partners with footwear brands to offer its soles on their shoes.

Hilos 3D Printed Shoes, Source: Hilos

Feetz is an American footwear company that produces 3D printed custom-made insoles. Feetz's insoles are made to order, which ensures a perfect fit and reduces waste. The company also uses recycled materials to produce its insoles.

Feetz 3D Printed Shoes, Source: Feetz

As 3D printing technology continues to develop and become more affordable, we can expect to see more and more footwear companies using 3D printing to produce sustainable shoes.

Step into the Future of Footwear at AMTECH – Additive Manufacturing Expo 2023.

Discover the latest trends in the Additive Manufacturing industry with 3D Printing in Footwear.

Check out the impressive display zone showcasing samples of 3D-printed footwear that are setting new benchmarks in style, comfort, and innovation. Network with 3D printing experts, visionary designers, and forward-thinking business owners who are redefining the footwear industry.

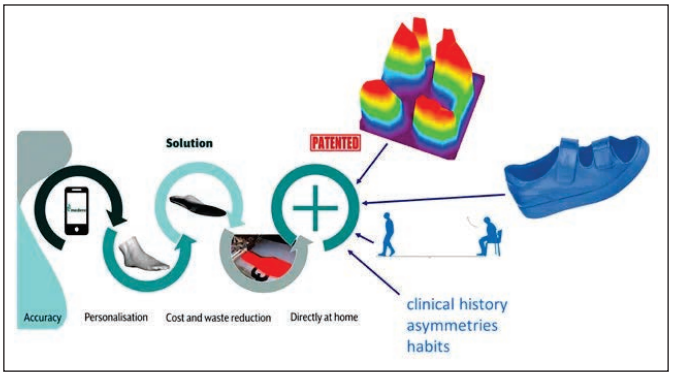
Join us at AMTech Expo and be part of the revolution in footwear technology on 1-2 December 2023 at Hitex Exhibition Centre, Hyderabad. Register and get your e-badge today

Medical Applications of 3D-Printed Footwear

Foot health is a priority for many individuals, and 3D printing is making a significant impact in this area. 3D-printed footwear has a number of potential medical applications such as Custom-made orthotics, Prosthetic footwear, Diabetic footwear & Footwear for children with special needs.

3D-printed orthotics can be made to perfectly fit the patient's foot, providing support and cushioning to relieve pain and improve mobility. Orthotics can be used

to treat a variety of conditions, including plantar fasciitis, heel spurs, and bunions. 3D-printed prosthetic footwear can be created to match the patient's residual limb precisely, providing a comfortable and functional fit. 3D-printed prosthetic footwear can be more affordable and easier to customize than traditional prosthetic footwear. 3D-printed diabetic footwear can be designed to protect the foot from pressure sores and other complications of diabetes.



3D-Printed Insoles for People with Type 2 Diabetes, Source: Mancuso, M.; Bulzomì, R.; Mannisi, M.; Martelli, F.; Giacomozzi, C. 3D-Printed Insoles for People with Type 2 Diabetes: An Italian, Ambulatory Case Report on the Innovative Care Model. Diabetology 2023, 4, 339-355. https://doi.org/10.3390/diabetology4030029

3D-printed diabetic footwear can be made with soft, cushioning materials and customized to fit the patient's individual needs. 3D-printed footwear can be created to address the specific needs of children with special conditions, such as cerebral palsy and spina bifida. 3D-printed footwear can help to improve the child's gait, balance, and posture.

In addition to these specific applications, 3D-printed footwear can also be used to create more comfortable and supportive footwear for people with a variety of foot conditions, such as flat feet, high arches, and wide feet.

3D Printed Shoes for prosthetics and orthotics patients of Shriners Hospitals for Children

Shriners Hospitals for Children is using 3D-printed footwear to create custom prosthetics and orthotics for its patients. This helps the hospital to provide correct solution to patients and reduce inventory. As 3D printing technology continues to develop and become more affordable, we can expect to see even more innovative and effective medical applications for 3D-printed footwear.

Conclusion

The future of footwear is taking a remarkable turn with 3D printing. From consumer preferences and sustainability to design innovation and medical applications, 3D-printed shoes are stepping into the mainstream. With various successful case studies it's clear that this technology is here to stay, changing the way we walk, run, and live.

ABOUT THE AUTHOR

Chinmay Saraf

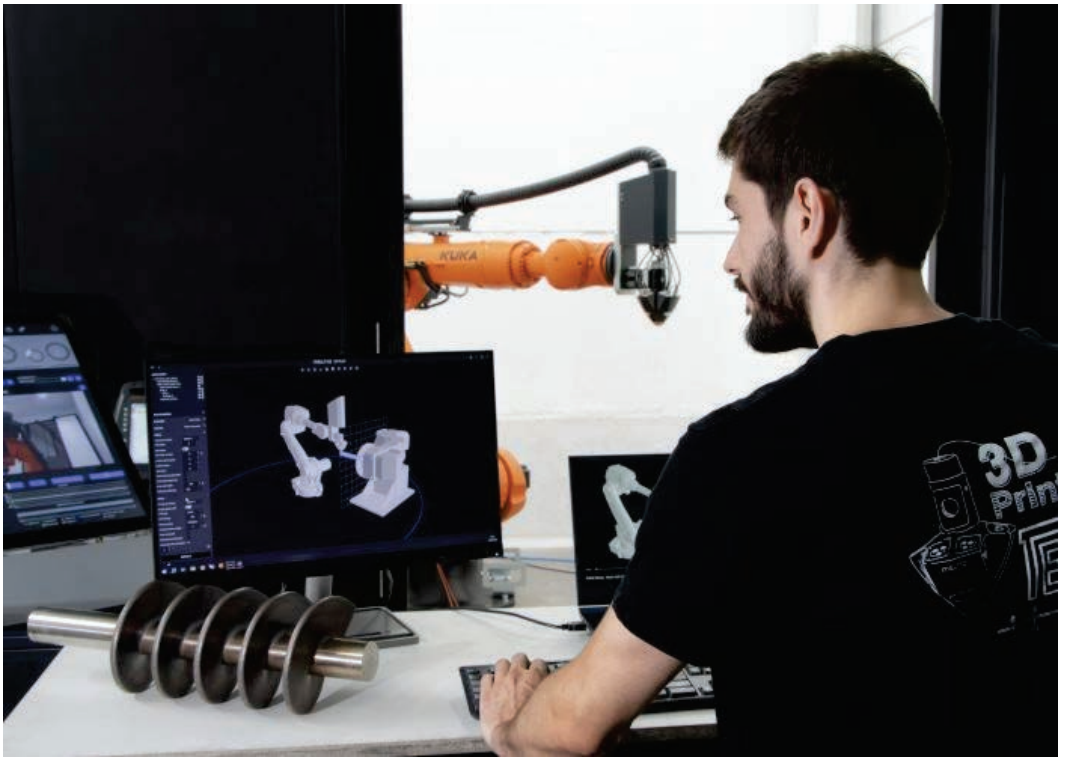
Technical Writer, AM Chronicle

Chinmay Saraf is a scientific writer living in Indore, India. His academic background is in mechanical engineering, and he has substantial experience in fused deposition-based additive manufacturing. Chinmay possesses an M.Tech. in computer-aided design and computer-aided manufacturing and is enthusiastic about 3D printing, product development

Meltio Boosts Metal 3D Printing for Robotic Arms: New Meltio Space and Meltio Robot Cell, the Ultimate Solutions to Create Reliable Large Industrial Parts

Alejandro Nieto Jiménez

The article explores Meltio two innovations to boost its metal 3D printing systems



Meltio unveiled two innovations to boost its metal 3D printing systems to answer all industrial applications linked to the use of an industrial robotic arm. Meltio is a manufacturer and developer of its unique wire-laser metal 3D printing technology for different industries. A technology created and patented in its unique Spanish factory in Linares (Jaén). With these two innovations, the Meltio Space software, and the new Meltio Robot

Cell, the company is responding to the increasing use of metal 3D printing in different industrial sectors by offering the best tools for its adoption focused on ease of use and affordability.

In recent months, there has been a worldwide growing demand from industries that incorporate the Meltio head on a robotic arm –Meltio Engine Robot Integration– to print and repair metal parts with wire-laser additive manufacturing technology. The most commonly used metals are stainless steels, titanium, nickel alloys like Inconel, and tool steels, among others.
To meet the rising demand for the industrial sector, Meltio has launched the Meltio Space toolpath generator software to facilitate the use of its metal 3D printing solutions. By offering a user-friendly interface and comprehensive features, this robot slicer simplifies the integration of Meltio's wire-laser metal 3D printing technology by offering a built-in robot library and postprocessors for some of the most popular robotic brands, including ABB, Kuka, FANUC, and Yaskawa.

This toolpath generator software for the Meltio Engine Robot Integration as well as for the turn-key solution Meltio Robot Cell, offers an easy-to-use interface for planar, nonplanar, and variable extrusion toolpaths. It also includes 2-axis workpiece positioner interpolation, kinematics simulation, collisions check, and cell configuration.

This slicer offers a new perspective on 3D printing by breaking free from the limitations of traditional 3-axis systems and expands the possibilities by incorporating advanced robotic manipulation capabilities. Featuring an intuitive design, users can quickly adapt to and leverage the benefits of robotic additive manufacturing (AM) without requiring expertise in robotics or programming.

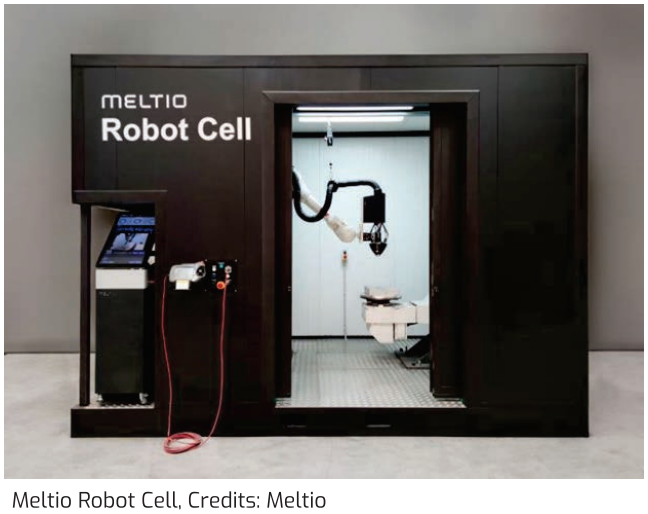
Also, Meltio Space goes beyond the constraints of traditional 3-axis systems. With its integration of a 6-axis robotic manipulator and 2-axis workpiece positioners, it opens up a new realm of possibilities for metal 3D printing. The comprehensive coordination, multi-axis toolpath generation, and enhanced design freedom provided by the software empower users to create intricate, customized, and highly detailed metal parts.

Meltio Space includes presets with recommended material profiles and 3D printing parameters. With a strong focus on user experience, it offers a fully tailored customer journey centered around the seamless integration between the Meltio Engine and Meltio Space. The software provides custom-developed Meltio print profiles included in the Meltio materials portfolio. With its intuitive design, users can quickly adapt to and leverage the benefits of robotic AM without requiring expertise in robotics or programming.

The Meltio Space robot slicer employs a virtual model of the real robot movement. This advanced feature enables users to simulate the kinematics of the robot, ensuring accurate and precise printing. Additionally, the slicer performs collision checks with the part being printed, minimizing the risk of errors or damage during the additive manufacturing process.

Meltio Robot Cell

The second recent innovation created by Meltio is the turn-key Meltio Robot Cell to boost the performance of a robotic arm converted into a system to 3D print metal parts in a safer, more reliable, and highly accurate way by controlling the entire process offering also the most competitive lead time, between 4 and 6 weeks.



Meltio Robot Cell, Credits: Meltio

In its vision as a patented Directed Energy Deposition (DED) 3D printing technology developer and manufacturer to accompany and be the reliable solution for industries around the world to adopt Meltio's wire-laser metal 3D printing solutions that reduce costs and improve manufacturing processes, the Spanish multinational presented a new hardware innovation: the Meltio Robot Cell. This new system includes a standard ABB robotic arm inside the cell and allows standard metal 3D printing starting from a build plate in a factory as well as for adding features or repairs on existing parts.

The volume and work area defined in the Meltio Robot Cell workspace meet all manufacturing needs using our industrial-level additive manufacturing technology to take full advantage of Meltio's metal 3D printhead and be able to manufacture parts in an industrial environment autonomously thanks to its monitoring and safety features. The robot and positioner are installed on a self-supporting platform, as well as a laser-safe enclosure together with the Meltio Engine, Meltio Space, and accessories.

With the Meltio Robot Cell, Meltio company is fulfilling most of the applications that industry and integrators need when printing industrial metal parts.

The Meltio Robot Cell is designed as a plug-and-play system, with a single electrical power supply and a single inert gas supply. The environmental conditions are standard and this cell cannot be outdoors or unprotected from the sun and dust, it must be in a controlled environment. This solution allows the customer to receive a product ready to use for robotic metal 3D printing.

The Meltio Robot Cell is certified and tested to operate with an ABB robotic arm as standard configuration and aimed at all industries. It is most certainly an evolution of the Meltio Engine Robot Integration as a base production model to enable industries to incorporate 3D printed parts manufacturing with the Meltio head integrated into a robot into their production systems.

As Meltio Engine Product Manager, Alejandro Nieto is excited about this new innovation:

“Meltio's main commitment with the launch of the Meltio Robot Cell is to offer all types of industries the ability to manage the entire manufacturing process using our metal 3D printing technology consisting of a Meltio head integrated into a robotic arm and in a safe environment, in order to just produce parts. This new hardware system allows the customer to receive a ready-to-use cell for robotic metal 3D printing, removing the integration process and long assembly lead times. The Meltio Robot Cell has a specific area for every supply the cell requires on a daily basis, only connecting to the inert gas and electric supply is enough to start manufacturing.

The Meltio Robot Cell also provides the industrial customer with a working protocol. Relative to existing offerings in the market today, the Meltio Robot Cell is very competitively priced and its price is below 300,000 dollars ex-works. The cost of the solution is also competitive when compared with thermoplastic and concrete 3D printing systems as seen in other sectors that demand 3D printing for structural parts. This cell has the possibility to be delivered with other robot brands on the market to be more responsive to customers in terms of availability and technical capability. The Meltio Robot Cell is compatible with the open hardware platform that allows Meltio to integrate our metal 3D printing head on any brand of robotic arms”.

For more information, please contact:
info@meltio3d.com
https://meltio3d.com/applications/

ABOUT THE AUTHOR

Alejandro Nieto Jiménez

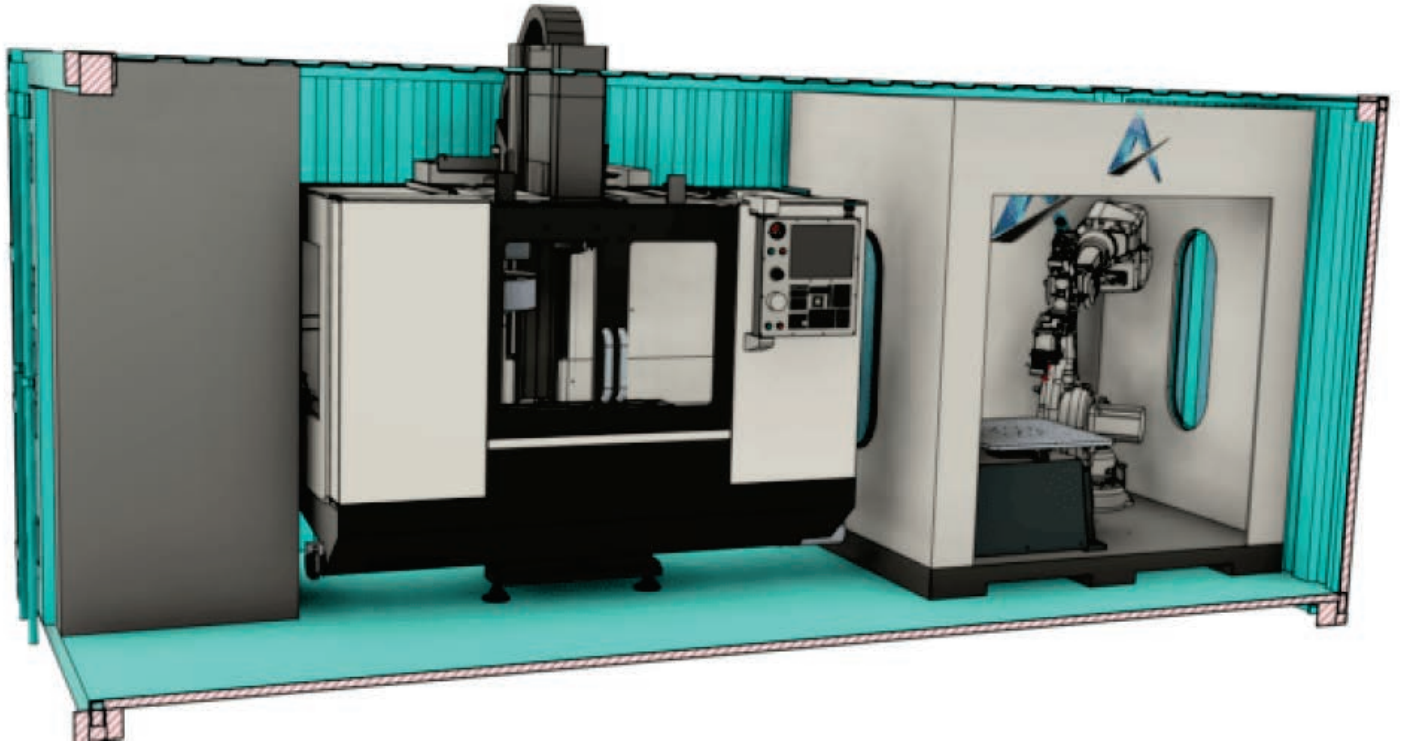
Meltio Engine Project Manager

Alejandro Nieto Jiménez is an experienced Meltio Engine Project Manager, his main goal is to develop technology capable of challenging standards and providing new solutions through research and technology.

Welcome to the Future of Deployable On-Demand Manufacturing

Sriram Manoharan

3D Metal Printing Using Deployable On-Demand Manufacturing



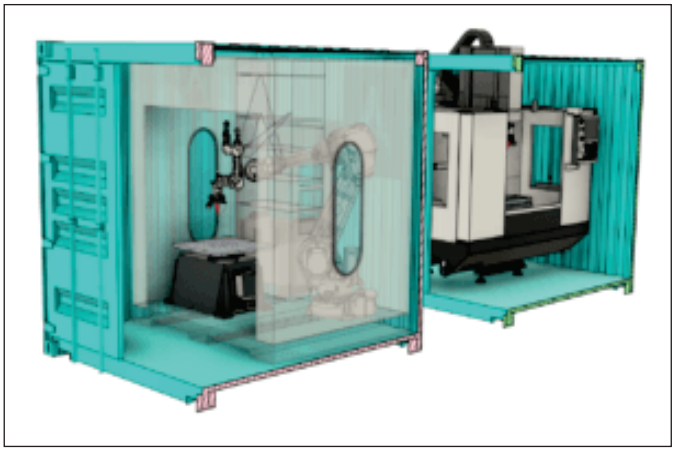
The recent pandemic was a true black swan event in that it shocked a lot of seemingly robust systems. This shock shattered the fragile supply chains of various manufacturing industries and even caused the halting of production lines in some cases. While normalcy is returning slowly, the industries have started reassessing their in-house manufacturing capabilities and are exploring various avenues to meet their needs.

Additive manufacturing (AM) can be of great help in this regard as it offers true design freedom free of conventional constraints, part count reduction through design consolidation and most importantly, on-demand manufacturing.

In the world of structures, metals and their alloys play a very indispensable role. Although there are multiple

implementations to 3D print metal parts, there are limited cost-effective metal AM systems in the market which can print metal parts on-demand at scale while not compromising productivity and resolution. To address this need, ADDiTEC offers a performance line of metal AM systems featuring a powerful 6 kW single fiber laser deposition head. The deposition heads work based on the principle of laser-wire Directed Energy Deposition (DED) where weld beads are precisely stacked according to CAD to create a 3D structure. The weld bead is created when wire is introduced into the laser generated melt pool. The deposition heads are mounted to commercially available robotic arms for producing highly complex parts with infinite degrees of freedom with no inherent constraints when the working envelope is only limited by the size of the motion system and enclosure.

Portable Performance AM System



After printing, the component can directly undergo machining or surface treatment along with heat treatment to create high precision fits with required mechanical properties. Typical bead widths for wire correspond to 1.2x the wire diameter, representing the lower wall thickness limit for wire 3D printing. The system can process standard MIG filler materials, ensuring excellent availability and low material prices globally. Typical layer heights range from 0.3-to- 1.2 mm and can be selected depending on the required surface finish and printing time.

Some salient features of this metal AM system:

- Material feedstock being wire, it is safe and cost-effective.
- No wire feedstock is wasted as all the wire enters the melt pool.
- Ability to print aluminum, copper, stainless steels, mild steel, carbon steels, Inconel and titanium alloys.
- Up to 4 kg/hr. deposition rate.
- As the heat affected zone is compact by virtue of the deposition technology, the printed parts have good surface finish, excellent strength, and exhibit near isotropic properties.
- Pyrometer data based closed loop control system for regulating melt pool temperature and wire feed rate.
- Sophisticated wire feed system with wire straightener for precise deposition.

To enhance mission-readiness through cost-effective production of products which are on-demand and point-of-need, either at the base, at sea, or on the frontlines, we have envisioned architectures for robotic hybrid manufacturing portable cells rated for conventional, reactive and refractory alloys. The portable cells provide all the benefits of a robotic architecture for additive and subtractive manufacturing in a compact hermetically sealed cell that is portable, allowing installation and the first printed parts in just one day making forward-deployable on-demand manufacturing a reality.

While robotic DED is scalable to very large sizes, it results in parts that are rough, near net shapes requiring post fabrication machining. Up to this point, parts are “printed” and then taken to machine shops for machining part features such as axle bores, threaded holes, etc. This post fabrication machining step is also used to reduce or eliminate surface roughness that results from the DED stacking of weld bead like layers during the build. For some potential applications of large-scale metals DED, the post fabrication machining step is logistically cumbersome and slows the overall

process. Furthermore, some parts may have internal features such as flow passages, for example, that cannot be machined after the total part build is completed because cutting tool access is not available. These issues lead to the notion of hybrid manufacturing where additive and subtractive processes are operationally integrated into an in-situ iterative process.

Highlights a single 40-foot Conex, equipped with portable robotic AM cell by ADDiTEC, CNC Mill (HAAS TM1), and heat treatment furnace.

Highlights a 20-foot Conex, equipped with portable robotic AM cell by ADDiTEC and second 20-foot cones with hybrid CNC Mill (HAAS TM1), with a 9 Technology Readiness Level and 5 Manufacturing Readiness Level.

Highlights portable robotic hybrid cell by ADDiTEC with additive and subtractive capabilities with an automatic tool changer. This innovative solution combines cutting-edge technology and portability to transform the additive manufacturing industry, eliminating logistical challenges associated with traditional additive and subtractive manufacturing setups while maintaining superior quality standards.

The hybrid DED systems by ADDiTEC can deliver on multiple fronts such as mobility, ruggedness, speed, reliability, ease of use and material readiness of "point-of-need" manufacturing. The system will advance and modernize manufacturing to quickly pivot and respond to demands. Establishing this deployable hybrid manufacturing capability will greatly improve self-reliance and better ensure optimal readiness for emergencies.

ABOUT THE AUTHOR

Sriram Manoharan

Sriram Manoharan, Ph.D. is an R&D Program Manager, ADDiTEC.

Sriram Manoharan has more than 3 years of experience in advance metal additive manufacturing and PhD research on understanding process-structure relationship in producing compositionally graded alloys using simultaneous wire-fed and powder fed laser directed energy deposition process (MELTIO M450).

Advancing Metal Manufacturing for R&D Labs with Next Generation Metal Atomizers

SRT

ATO metal atomizers for R&D Labs

Metal Atomizers are advanced technological solutions used to manufacture metal powders, and the interest in these systems is increasing. They utilize high-pressure gas or centrifugal forces to break down molten metal into fine droplets or powder to create necessary powders for various applications. In the case of various metal additive manufacturing methods, metal powders play a significant role as high-quality metal powders directly impact the quality of the end product.

This article explores the basics of Metal atomizers and highlights the challenges faced by research and development labs with powders and the role of ATO metal atomizing systems in solving their various challenges.

Metal Atomizers

Metal Atomizers use techniques to break molten metal into fine droplets or powder. The working principle of these systems can vary depending on the specific technology employed. Metal Atomizers find applications across a wide array of industries.

ATO metal atomizing systems utilize the power of ultrasonic vibrations to break down molten metal into small droplets, which rapidly solidify into metal powder within an inert gas-protective atmosphere. The frequency of the ultrasonic vibrations influences the size of the metal powder particles. Higher frequencies result in smaller particles, while lower frequencies produce larger particles. Other factors that affect particle size and distribution include viscosity, density, ultrasonic amplitude, and the design of the atomizer itself. Ultrasonic atomization using ATO technology begins with introducing the raw material into a pressurized atomization chamber. An electric arc is generated within the chamber to melt the material, forming a molten metal bath. Ultrasonic vibrations are transmitted through a sonotrode, a component that contacts the molten metal bath. This technology ensures that ATO's systems can be used in various industries.

Metal Atomizing in Metal Additive Manufacturing

Metal atomizers play a pivotal role in metal additive manufacturing. By transforming molten metal into fine powder particles, these systems enable the creation of intricate and complex geometries with high precision.
ATO Lab Plus

The metal powders are used in various metal additive manufacturing methods such as direct energy deposition, powder bed fusion, binder jetting, and sheet lamination.

Several atomization techniques are employed to produce metal powders with varying properties. Gas atomization involves spraying molten metal through a nozzle with high-pressure gas, resulting in highly spherical powders with narrow particle size distribution. Plasma atomization employs a high-energy plasma torch to melt and atomize metal feedstock, allowing for excellent control over particle

ATO Lab Plus

size distribution and the production of both spherical and non-spherical powders. The choice of atomization technique depends on the desired powder properties, cost considerations, and specific application requirements, allowing for the continuous advancement of manufacturing capabilities in various industries.

Advantages of ATO atomizer over traditional systems for R&D Labs

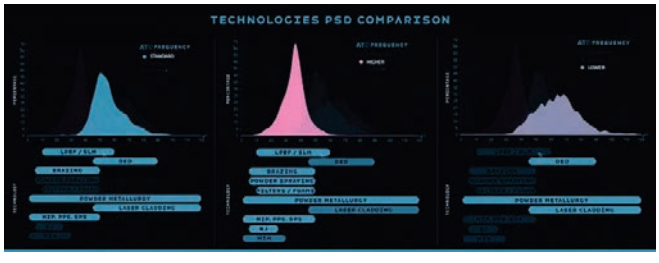
In the metal atomization process, metal powders of varying sizes are produced, which are used for various metal additive manufacturing and powder metallurgy applications. The ATO atomizer can achieve a narrow particle size distribution ranging from 20 to 120 µm, which can be used for specific Research and development purposes.

The average order size for metal powders ranges from 100-150 kgs when procured from any metal powder supplier. The large average order size is a significant constraint for most research and development labs. With the ATO atomizer, the research and development labs can manufacture powders in limited quantities, reducing costs.

The other challenges that research and development labs face are the availability of a limited number of materials. The ATO atomizer system offers remarkable capabilities for producing metal powders. This advanced technology allows for producing metal powders from various materials, including refractory and high entropy metals, with melting temperatures of up to 3400°C. This expanded material compatibility opens up a broader range of research and development applications.

The ATO atomizer system can also be used for large-scale research and development projects, as powders can be manufactured in small and large batches. In addition, its lab fit design also solves the availability-related challenges faced by the labs.

One standout feature of the ATO atomizer is its ability to achieve a narrow particle size distribution. This is achieved through the influence of ultrasonic waves, which can be adjusted by manipulating the ultrasonic frequency and other parameters. This level of control allows the atomizer to generate metal powders of different sizes and shapes to meet specific application requirements, making it an incredibly customizable system. These powders exhibit extremely low oxygen content, ensuring their suitability for reactive alloys. The powders also boast high particle sphericity and excellent flowability, making them ideal for reactive and non-reactive alloys. The innovative sonotrode used in the system eliminates contamination and guarantees a stable and repeatable atomization process.



Technologies PSD Comparison

The ATO metal atomizer system's key features include its lab-fit size, which overcomes compact workplace requirements. Post-installation, the system can produce low oxygen content, high particle sphericity, and excellent flowability for day one. Additionally, ATO processes a range of reactive & non-reactive alloys (steel, aluminum, titanium, nickel-based, and many more), making it ideal for commercial & research needs. The systems also ensure reduced costs and quickly optimize processes with custom powders at a reasonable cost.

Conclusion

Metal atomizers have revolutionized metal manufacturing by providing a versatile and efficient method for producing high-quality metal powders. The emergence of cutting-edge systems like the ATO atomizer further pushes the boundaries of achievable goals, empowering industry professionals to innovate and transform how metals are used in manufacturing.

With the continuous advancements in metal atomization technology, we can expect further breakthroughs in material science and engineering, opening up new possibilities for metal-based products in the future.

ABOUT THE AUTHOR

Shree Rapid Technologies (SRT)

Shree Rapid Technologies (SRT) is a pioneer in 3D Printing Technology and incorporated in 2007. They are specialized in cutting-edge technology into 3D Printing, 3D Scanning and Measurement that enables us to design, validate and create precise and intricate 3D prototypes and end use parts. They cater to variety of applications in multiple industries line Aerospace, Automotives, Bio Printing, Dental, Jewellery, Machine Tooling, Medical Devices, Service Bureaus, etc.

Their state-of-the-art Customer Innovation Center (CIC) is laced with advanced 3D Printers, 3D Scanners, Metrology and Inspection.

To visit the experience center or any other query kindly mail at : marketing@shreerapid.com

Contact Number: (+91) 7208843624 / 022-67415403

Al Seer Marine and Abu Dhabi Maritime create Guinness World Record for 3D Printed Water Taxi

Aditya Chandavarkar

Story on Guinness World Record for 3D Printed Water Taxi

A groundbreaking moment in maritime innovation unfolded as Al Seer Marine and Abu Dhabi Maritime, part of AD Ports Group, unveiled the world's first 3D printed water taxi, shattering The Guinness World Records™ title for the Largest 3D printed boat. This historic achievement not only symbolizes a remarkable leap in sustainable transportation but also signifies a monumental stride towards a greener and more inclusive future.

Capt Saif Al Mheiri, Managing Director at Abu Dhabi Maritime, echoed the sentiment, emphasizing the synergy between Al Seer Marine and Abu Dhabi Maritime. "Our partnership has given birth to something truly extraordinary. This 3D printed water taxi represents a significant leap forward in sustainable maritime transportation and a unique experience for our customers."

Crafted with precision from recycled PIPG (30% glass fiber and UV stabilizer), the 11.980-meter-long and 3.594-meter-wide water taxi stands tall as a testament to recycling and advanced manufacturing. Its design, a harmonious blend of innovation and functionality, accommodates 29 passengers with ease, crew included, while offering dedicated spaces for bicycles and wheelchairs. This amalgamation of eco-consciousness and practicality is set to redefine the landscape of modern transportation. This 3D printed boat is planned to be utilised within Abu Dhabi's water taxi network in late 2024.

"This record-breaking accomplishment is a testament to our unwavering dedication to sustainable practices and pioneering engineering," proudly stated Guy Neivens, CEO of Al Seer Marine. "Beyond achieving a The Guinness World Record, this endeavor serves as a clarion call to the industry, urging the adoption of greener technologies. We take immense pride in crafting this extraordinary water taxi within our very own facility, a beacon of our commitment to a sustainable future."

Beyond its groundbreaking construction method, the water taxi's innovative design seamlessly integrates bicycles and wheelchairs, ensuring accessibility for all passengers, regardless of their mobility needs. This emphasis on inclusivity underscores the commitment of Al Seer Marine and Abu Dhabi Maritime to creating a transportation solution that serves everyone.

Al Seer Marine and Abu Dhabi Maritime stand on the precipice of a new era in maritime transportation. Their

collective achievement propels the industry towards a more sustainable, inclusive, and environmentally friendly future. As we celebrate this monumental milestone, let us join hands and embark on this historic journey towards a tomorrow where innovation and sustainability harmonize, leaving an indelible mark on maritime history.

About Al Seer Marine

Al Seer Marine Supplies and Equipment is a publicly listed company in the Abu Dhabi security exchange market (ADX: ASM); it was established in 2003 and is headquartered in Abu Dhabi, UAE. Al Seer is a leading global marine company headquartered in Abu Dhabi, with a portfolio of services including 18 vessels, management and training, Construction of vessels, High-tech boatbuilding, Unmanned systems development, and manufacturing. Al Seer Marine employs more than 1200 people onboard and ashore from more than 50 nationalities.

About Abu Dhabi Maritime:

Abu Dhabi Maritime was established in 2020 as the primary custodian of Abu Dhabi's waterways and marine ecosystems. Operating under AD Ports Group, in cooperation with Department of Municipalities and Transport (DMT), Abu Dhabi Maritime governs and regulates Abu Dhabi's maritime sector by providing world-leading maritime infrastructure, while ensuring the emirate implements the highest standards of health, safety, environment, and quality.

For more information please visit: admaritime.ae

ABOUT THE AUTHOR

Aditya Chandavarkar

Managing Editor, 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.

Revolutionizing Healing: The Era of 3D-Printed Orthotics

Manoj Pillai

Benefits, applications and recent case on 3D printed Orthotics

In recent years, advancements in 3D printing technology have been reshaping various industries, from aerospace to healthcare. One particularly transformative application has emerged in the field of orthopedics – the 3D-printed immobilization devices. This innovative approach to immobilizing and supporting fractured limbs is changing the way we approach injury recovery.

The world of medicine and technology is witnessing a groundbreaking development with the emergence of 3D printed Orthotics. Traditionally, when a person suffers a leg fracture or injury, they are fitted with a heavy, uncomfortable plaster cast that often leads to inconvenience and discomfort during the healing process. However, 3D printing technology is changing the game, offering a more patient-friendly and efficient solution.

In this article, we will delve into the world of 3D-printed

orthotics, exploring their benefits, applications, taking example of a recent case done by Falcon Technologies International along with RAK Hospital.

The Traditional Leg Cast

For decades, the conventional plaster cast has been the go-to solution for immobilizing and supporting fractured and injured limbs. While effective in its purpose, plaster casts have several drawbacks. They are heavy, uncomfortable, and often cause skin irritation. Furthermore, their application is a time-consuming process, requiring skilled technicians and multiple layers of casting material.

Conventional Cast vs. 3D printed customized cast

The Emergence of 3D-Printed Orthotics

3D printing, also known as additive manufacturing, has opened up new possibilities for customizing medical devices. With the ability to create intricate, patient-specific designs, 3D printing has revolutionized the field of orthopedics.

Benefits of 3D-Printed Leg Casts

Customization: Perhaps the most significant advantage of 3D-printed leg casts is their ability to be tailored to each patient. Through quick surface scanning of a patient's limb using Structured light scanner, the 3D Image of the patient limb is available, and a cast can be precisely designed to match the contours of the patient's limb. This level of customization ensures a snug and comfortable fit, reducing pressure points and enhancing overall comfort.

Lightweight and Breathable: Unlike traditional plaster casts, 3D-printed casts are considerably lighter and allow for better ventilation. This results in improved patient comfort and a reduced risk of skin irritation.

Maceration of Skin due to plaster

Hygiene and Maintenance: 3D-printed casts are waterproof, allowing patients to shower and swim without compromising the integrity of the cast. This significantly improves hygiene during the recovery period. Additionally, these casts are less likely to develop cracks or deteriorate over time, reducing the need for frequent replacements.

Improved Healing: The precision of 3D-printed casts ensures that the injured limb is immobilized effectively, promoting proper alignment and faster healing. The reduced weight also means less strain on the patient's body during the recovery process.

R**emovable and Reusable:** The 3D printed cast can be removed very easily and worn back. This will help the doctors to examine the patient incase of any issues and can be worn back every easily.

Process of Making a 3D Printed Leg Cast

Biocompatible material: The 3D printed cast is made of Bio compatible, PA 12 polymer.

Made in FTI Ras Al Khaimah – The only 3D printing facility in the region which is ISO 13485 Certified and GMP Certified by MOH for Medical devices manufacturing.

Patient Experience and Rehabilitation

The patient experience is a crucial aspect of healthcare, and 3D printed leg casts significantly enhance it. Patients report feeling more comfortable, less restricted, and generally happier with 3D printed casts compared to their traditional counterparts. This improved comfort often results in better compliance with treatment plans, leading to faster and more successful recoveries. The designs can be very trendy and improves the metal state of the patient while wearing the cast. Moreover, the lightweight and breathable nature of 3D printed casts allows patients to engage in certain physical activities and exercises, promoting better muscle tone and overall rehabilitation.

Challenges and Future Prospects

While 3D printed leg casts offer numerous advantages, they are not without challenges. Some patients may still require traditional casts due to the severity of their injuries. The cost of 3D printed casts can be higher. The hospital staff needs to be trained to capture the body contour scan. There could be an additional visit required to hospital to don the 3D printed orthotics. Since it is a customized product, from the body contour scan to manufacture, it could take 24 hours. Insurance approval is another area which needs to be addressed. However, as the technology advances and becomes more widely adopted, these challenges are expected to diminish.

Conclusion

The advent of 3D-printed orthotics represents a significant leap forward in the field of orthopedics. By combining precision, customization, and comfort, these casts are poised to revolutionize the way we approach limb immobilization and support during the recovery process. As technology continues to evolve, we can anticipate even greater strides in patient-specific care, ultimately leading to faster, more comfortable recoveries for those with orthopedic injuries.

ABOUT THE AUTHOR

Manoj Pillai

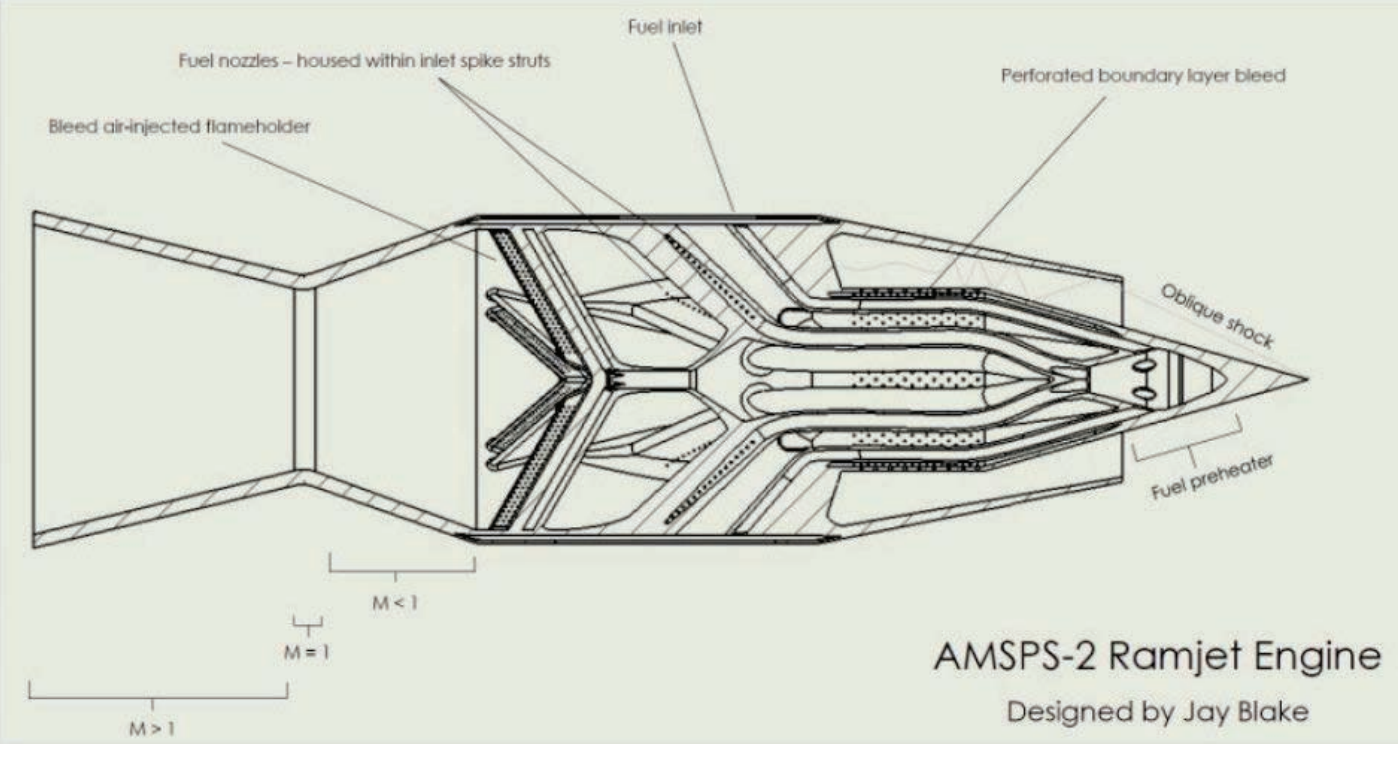
AVP Commercial, Additive manufacturing at Falcon Technologies International LLC

Manoj Pillai is AVP Commercial , Additive Manufacturing at Falcon Technologies International LLC and Leading the AM division of Falcon Technologies International.

Fueling Advanced Ramjet Designs with Velo3D Metal 3D Printing

Sarto Electro Equipments Pvt. Ltd

The case study on ramjet engine designed by Velo3D in partnership with Lockheed Martin



This ramjet engine designed by Velo3D Applications Development Engineer, Jay Blake, was developed in partnership with Lockheed Martin to demonstrate the industrial maturity of emerging in-situ process monitoring capability in the latest generation of laser powder-bed fusion additive manufacturing (AM) systems. It is designed for small unmanned reusable or nonreusable aircrafts flying at supersonic speeds. This display piece was printed on a 1-meter-tall Sapphire XC 1MZ in Inconel®718 as a solid piece without supports.

It was made possible with funding through LIFT, the Detroit-based national manufacturing innovation institute, in partnership with the Department of Defense.

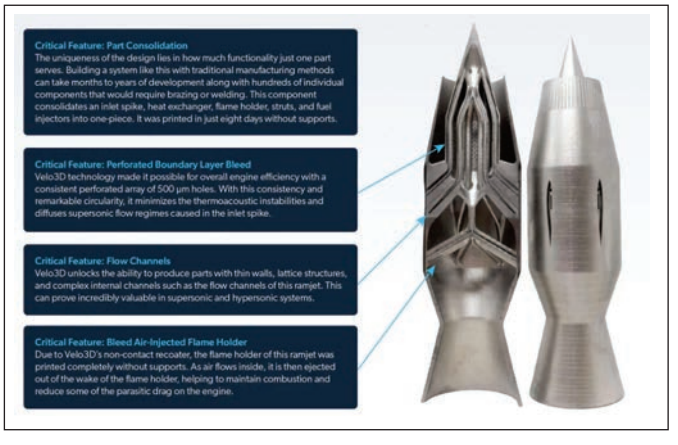
Challenging Traditional Manufacturing

One of the major challenges in traditional manufacturing is achieving high aspect ratio structures

while ensuring performance and efficiency gains. While studying this design, there was potential performance gain in using the fuel as a heat sink to manage aerodynamic heating while delivering hotter fuel to the combustor. Research suggested a performance increase by injecting bleed air into the wake of the flame holder, reducing parasitic drag while maintaining combustion efficiency.

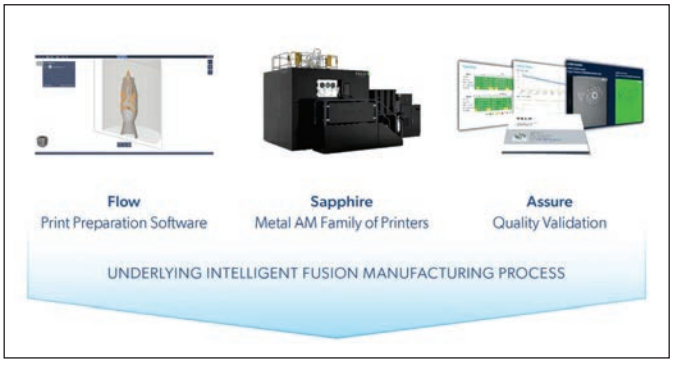
Applying Velo3D's Advanced Metal Additive Manufacturing Technology

With Velo3D technology, our engineer was able to incorporate these performance and efficiency features with great dimensional accuracy despite the design's intricate internal channels. This part demonstrates the incredible benefits of AM including component consolidation, rapid prototyping, and complex internal architecture which would not be manufacturable with traditional manufacturing technology.



The Velo3D Fully Integrated Metal Additive Manufacturing Solution

Velo3D is at the forefront of innovation, pioneering an



integrated advanced metal AM solution that combines pre-print design, advanced printing hardware, and in-situ quality assurance, all unified into one intelligent system. Our solution is built for reproducible, predictable outcomes for scalability without compromising design complexity or functionality.

By leveraging advanced metal AM, defense organizations can spearhead the advancement of critical part design that will drive our military into the future and create more agile supply chains. Engineering teams can discover new avenues for efficiency and performance in key components of engine systems.

For more details about Velo3D in India contact Sarto Electro by sending an email to to rohil@sartoelectro.com

ABOUT THE AUTHOR

Sarto Electro Equipments Pvt. Ltd.

Sarto Electro Equipments Pvt. Ltd. represent EnvisionTEC GmbH, VELO 3D from USA , ZORTRAX from Poland - Rapid Prototyping Machines, Concept Laser GmbH, used in Jewellery Manufacturing, Dental Labs, Hearing Aids, Engineering, Defence, Aeronautical, Space, Gas & Turbine applications.

Navigating the Landscape: Important Additive Manufacturing Standards

AM Chronicle Editorial Team

Important Additive Manufacturing Standards that AM Professional Should Know

As the 3D printing industry continues to grow, the need for standardized practices becomes increasingly apparent. Additive Manufacturing (AM) standards are crucial for ensuring the quality, safety, and widespread adoption of AM technology. These standards provide a common language, guidelines for material selection and design, process specifications, and testing procedures, fostering consistency and reliability across the AM industry. Key organizations like ASTM International, ISO, and SAE International are actively developing and updating AM standards, addressing the evolving needs of various industries. The benefits of adhering to AM standards include enhanced product quality, reduced costs, improved safety, and expanded market access. As AM technology continues to advance, maintaining up-to-date standards will be essential for ensuring its responsible and impactful utilization.

In this article, we will explore some of the most crucial

additive manufacturing standards that guide the industry toward greater efficiency and uniformity.

ASTM F42 Committee Standards

The ASTM International Committee F42 on Additive Manufacturing Technologies serves as a central hub for developing and maintaining standards in the field. Standards such as ASTM F2792 for file formats and AMF (Additive Manufacturing File Format) and ASTM F2971 for design principles aim to enhance interoperability and streamline the digital aspect of AM. Additionally, ASTM F3055 focuses on process-specific standards, offering guidelines for metal powder bed fusion processes.

ISO/ASTM 52900:2015 - Additive Manufacturing – General Principles

This international standard, developed jointly by the International Organization for Standardization (ISO) and ASTM, provides a comprehensive overview of additive manufacturing concepts, terms, and general principles. It serves as a foundation for other standards, offering a common language and understanding across the industry.

ISO 17296-1:2014 - Additive Manufacturing – General Principles – Part 1: Terminology

Terminology is a critical aspect of any industry, and additive manufacturing is no exception. ISO 17296-1 establishes a standardized vocabulary for AM, ensuring that stakeholders, regardless of location or specialization, can communicate effectively and avoid misunderstandings.

DNV-ST-B203: Additive Manufacturing of Metallic Parts

DNV-ST-B203 is an internationally recognized standard for the qualification, purchasing, quality management, and manufacturing of additively manufactured (AM) metallic parts. The standard provides a comprehensive framework for ensuring the quality and reliability of AM metallic parts and covers a wide range of topics, including design for AM, material selection, process selection, qualification of AM parts, purchasing of AM parts, quality management for AM parts, and manufacturing of AM parts. The current version of the standard is DNV-ST-B203:2020.

ISO 52910:2019 - Additive Manufacturing – Design – Design Requirements for Additive Manufacturing

This standard focuses on the design aspects of additive manufacturing. It provides guidelines for designing products that take full advantage of the benefits and capabilities offered by additive manufacturing processes. By adhering to these standards, designers can optimize their creations for efficiency, cost-effectiveness, and performance.

ASTM F3122 - Guide for Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes

Ensuring the mechanical integrity of additively manufactured parts is crucial for applications ranging from aerospace to healthcare. ASTM F3122 provides a guide for evaluating the mechanical properties of metal materials produced through additive manufacturing. This standard assists in determining the performance characteristics and reliability of AM-produced components.

End Notes

In additive manufacturing, standards are crucial for the industry to work together. They provide a framework for quality, consistency, and innovation. As the technology continues to evolve, these standards will play an increasingly vital role in fostering collaboration, ensuring safety, and propelling additive manufacturing into new frontiers. Staying abreast of and adhering to these standards will be essential for companies and professionals looking to thrive in the rapidly expanding realm of additive manufacturing.

ABOUT THE AUTHOR

AM Chronicle Editorial Team

The AM Chronicle Editorial Team is a collective of passionate individuals committed to delivering insightful, engaging, and accurate news and stories to additive manufacturing audience worldwide.

AM NEWS

RusselSmith and AM Chronicle Forge Strategic Marketing Partnership in Additive Manufacturing

RusselSmith, a leading provider of Integrated Energy Solutions in West Africa, and AM Chronicle, a prominent platform dedicated to promoting Additive Manufacturing (AM) technology, are pleased to announce a strategic marketing partnership that is aimed at advancing the Additive Manufacturing Industry.

The collaboration between RusselSmith and AM Chronicle is founded on a shared commitment towards the growth and development of Additive Manufacturing in West Africa, and Africa at large.

By joining forces, RusselSmith and AM Chronicle aim to foster innovation, facilitate knowledge exchange, and promote collaboration within the Additive Manufacturing ecosystem in Africa. This partnership represents a significant step forward in the promotion and development of cutting-edge Additive Manufacturing solutions in the region.

"We are excited about the opportunities that this partnership presents for both our organizations and the entire Additive Manufacturing community. As a pioneer of industrial 3D printing in Nigeria, our vision is that of an Africa where companies have access to rapid and on-demand distributed local manufacturing, to enable them reduce inefficiencies in the supply chain by producing fully functional parts in sustainable ways, to support research and development, and to spur economic growth. Together with AM Chronicle, we will drive progress and innovation in this dynamic field," said Effiong Okwong, Vice President at RusselSmith.

"We are delighted to collaborate with RusselSmith, a renowned West African energy industry leader, to advance Additive Manufacturing in the region. This partnership signifies our commitment to promoting technological advancements that will drive economic growth and sustainability," added Aditya Chandavarkar, Managing Editor and Co-Founder at AM Chronicle.

Kerala's First 3D Printed Building to be Opened at Thiruvananthapuram

'Amaze 28', the first-ever 3D printed building in the state constructed by the Kerala State Nirmithi Bhavan, at the PTP Nagar KESNIK campus will be opened to the public on Tuesday. The construction of the 380 sq. feet single hall building was completed within 28 days, whereas the 3-D wall printing took only 2 days. Minister of revenue and housing, Kerala, K Rajan will inaugurate the newly constructed environment-friendly building at 11am.

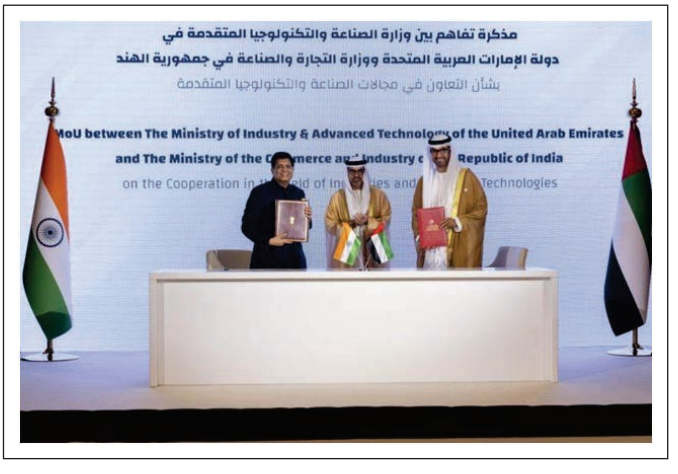
Compared to conventional construction methods the new technology saves time and labour costs. With 3D printing technology, the construction becomes quicker, hassle-free, and precise. The robot, which works based on the inputs from the software, precisely executes layer-by-layer printing with computerized mixing that uses fine aggregates, cement, and an admixture to reduce the setting time. The construction of the 380sq

feet building with a 3-meter height and fabricated openings cost Rs 11 lakh.

The chief technical officer of KESNIK, Jayan Ravindran, said that State Nirmithi Kendra took the initiative to publicize a cost-effective and environment-friendly technology in building construction. "3-D printing technology is not new to the world, but in our country the constructions using 3-D technology are rare and those technologies are developed by foreign countries. But a year ago we came across Chennai IIT's start-up 'TVASTA' as they have developed indigenous software for 3-D printing. We had done research on the technology and finally took the initiative to execute the same," Ravindran said.

"3-D printing technique is a game changer as it reduces the labour, time, and miscellaneous cost for the construction of a building. The new technology will be 3 times faster than the normal construction span and any complex designs can be easily printed," said Dr. Febi Varghese, director and CEO of Kerala State Nirmithi Bhavan.

UAE-India industrial deal identifies AM and other key areas to work together



The UAE and India will cooperate in seven vital areas to achieve sustainable industrial development, besides focusing on facilitating industrial investments, technology transfer and deploying key technologies in industries.

The seven key areas are supply chain resilience, renewable energy and energy efficiency, health and life sciences, space systems, AI, Industry 4.0 and advanced technologies, as well as standardisation and metrology. For this, the two countries signed a memorandum of understanding (MoU) which will benefit both the countries through joint industrial and technological developments.

The MoU was signed in the presence of Sheikh Hamed bin Zayed Al Nahyan, Member of the Abu Dhabi Executive Council. It was signed by Dr Sultan Al Jaber, UAE Minister of Industry and Advanced Technology and Piyush Goyal, India's Minister of Commerce and Industry.

High Level Joint Task Force

The MoU signing is in line with the UAE-India Comprehensive Economic Partnership Agreement (CEPA), aimed at enhancing the country's position as a gateway for trade and logistics. The agreement was signed during the 11th meeting of the UAE-India High Level Joint Task Force on Investments.

Dr Al Jaber said: "In line with the UAE leadership's vision, we are committed to strengthening bilateral relations to enhance sustainable and economic growth. Given the UAE's strong relationship with India across the economic, technological, and social domains, we are pleased to sign this MoU to further develop the industrial sector in line with advanced technology and sustainability standards.

"This aligns with the objectives of the national industrial strategy, and 'Make it in the Emirates' initiative, aimed at transforming the UAE into a global hub for advanced industry, especially industries of the future."

He added: "The MoU encompasses various aspects of cooperation aimed at promoting industrial investments in priority sectors for the national economies of both countries, including advanced industries, energy transition solutions, healthcare, and space. It also aims to develop innovative and technological solutions that

support sustainability and climate neutrality efforts. By working closely within these strategic sectors, the UAE and India can accelerate sustainable growth and diversify their economies, promoting industries that are more competitive, efficient, and sustainable."

Goyal commented: "This MoU opens new doors to develop cooperation efforts and build an institutional framework in the fields of emerging technologies. It will help in promoting and developing bilateral cooperation in sectors such space, healthcare, renewable energy, artificial intelligence, and many other vital areas."

To build supply chain resilience, the UAE and India will collaborate to identify opportunities to supply raw materials. They will also share best practices on industrial enablement and incentivisation for industrial growth and development, for instance in areas such as energy, land, CAPEX, OPEX, technology and labour.

In the energy space, the UAE and India will collaborate in advancing energy storage technologies, Smart Grid and IoT deployment, and R&D in renewable energy and energy efficiency. Similarly, in health and life sciences, the countries will collaborate in the development of pharmaceuticals, the use of biotechnology, and R&D.

The UAE and India are also seeking to enhance their respective space industries through closer collaboration in space systems. The MoU will help the countries to collaborate in the commercial development, launch and use of small satellites for communication and Earth observation, as well as space exploration. The countries will also collaborate in the development of licensing of space-related materials, in addition to R&D in the space sector.

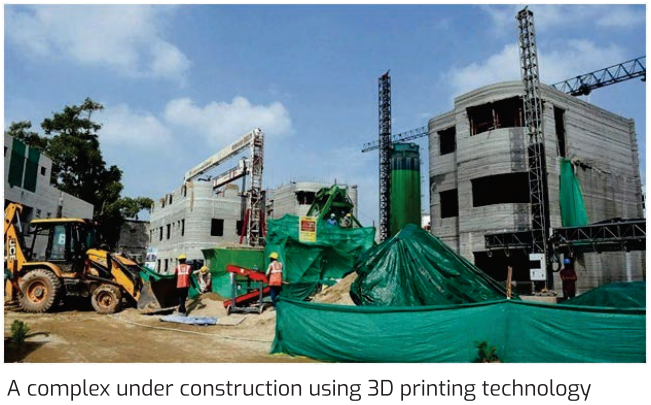
In the field of AI, the UAE and India will cooperate in the deployment of AI technologies in the space sector, energy, healthcare and supply chains. Both countries will work together to advance capabilities in machine learning and data analytics across priority sectors.

Under the MoU, the UAE and India will also collaborate in the deployment of 4IR technologies in industry, real-time data processing, the development of machine-to-machine control systems, the development of autonomous robotics, equipment and vehicles, as well as the deployment of additive manufacturing in key industries.

The final area of collaboration is standardisation, metrology, conformity assessment, accreditation, and Halal certification. The countries will exchange information including procedures, guidelines, and lists of regulated products. The countries will also cooperate to harmonise standards with international requirements and work towards the mutual recognition of the conformity assessment results.

Under the MoU, cooperation includes industrial and academic collaborations as well as collaborative research and development projects. The countries will also share best practices relating to science and technology policies.

Largest 3D printed complex coming up in Chandigarh; BRO chief reviews progress



A complex under construction using 3D printing technology near Air Force Station, Behlana. NITIN MITTAL

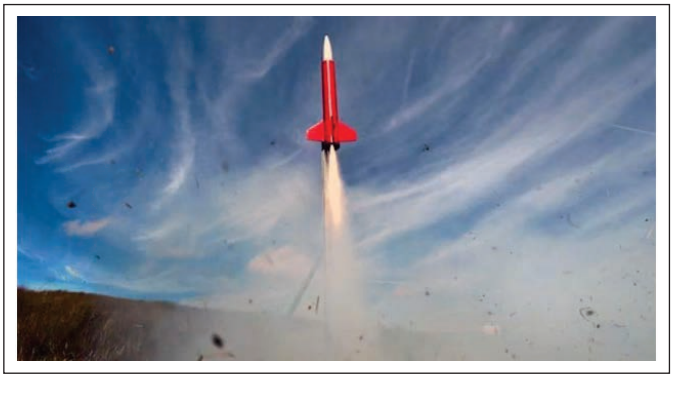
The world's largest 3D printed accommodation complex is coming up in the city. It is being built by the Border Roads Organisation (BRO) to provide transit support facilities to personnel and equipment en route to Ladakh.

Lt Gen Rajeev Chaudhry, Director General Border Roads, visited the site at BRO's Himank Air Dispatch Unit today to review the ongoing construction works, which is being executed by Larsen and Toubro. He said this was a new technology being adopted for construction and India was emerging as a global frontrunner in this field. The project boasts of the world's largest 3D printing machine that has been developed indigenously.

The campus will have six building blocks, of which five are being constructed using 3D printing technology and one with precast technology. The 3D printing technology along with solar studies and building simulations have been used to create climate sensitive built form to suit Chandigarh's weather conditions.

The campus will include accommodation, catering and other facilities for officers and other ranks along with an administrative building and storage facilities spread over 1.98 acres. The buildings will have three storeys as 12 m is the maximum height that can be achieved with the technology. Lt Gen Chaudhary said the construction of another 3D printed complex would be taken up in Ladakh, which would be larger than the ongoing project. It would house a BRO museum, showcasing the history and achievements of BRO and all its units. The BRO chief also commended BRO personnel for their dedication to duty. Among those present were Harendra Kumar, Additional Director General BRO, Brig Gaurav S Karki, Chief Engineer Project Himank, Col KS Lavana, Commander 753 Task Force, and Ramachandra SA, project manager.

Agnikul Is Planning to Build a 3D Printed Rocket & Launch It to Space



Chennai-based startup Agnikul plans to 3D print a space craft and launch it to the lower Earth orbit in a few days. At the core of this enterprise's ambitious plans is the creation of "Agnibaan," a small satellite launch vehicle engineered to transport payloads weighing up to 100 kilograms into a low-Earth orbit. This marks a significant leap in the private space industry.

This engine is notably characterized as "semi-cryogenic" and employs a unique combination of liquid kerosene at room temperature and supercold liquid oxygen to propel the launch vehicle into the vast expanse of space.

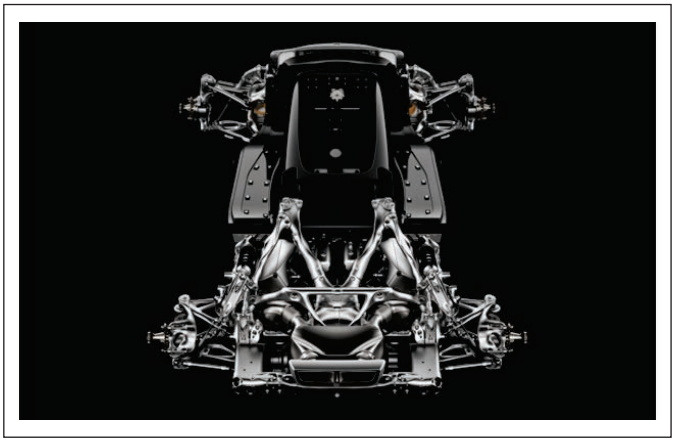
Agnikul disclosed that it initiated the integration process for its "Agnibaan SOrTed" (SubOrbital Technological Demonstrator) in August of the current year. The intricate integration operations are currently underway at the company's specialized facility situated at the Satish Dhawan Space Centre (SDSC) SHAR, nestled within the coastal town of Sriharikota.

Notably, the Agnikul launchpad and the Agnikul mission control centre is strategically positioned approximately four kilometres apart, and collectively constitute India's maiden private launch facility. This historic space hub was officially inaugurated on November 28 of the previous year by the esteemed Chairman of the Indian Space Research Organisation (ISRO), Mr. S. Somanath.

The recent injection of capital marks a significant milestone for Agnikul, signifying the resolute progress toward achieving its vision of revolutionizing the space launch industry. With Agnibaan and Agnilet in the works, this Chennai-based startup is poised to make a lasting impact on the future of space exploration.

Divergent Technologies, Inc. Announces Closing of Upsized $230 Million Series D Capital Raise

Divergent Technologies, Inc. ("Divergent"), the company that has invented, developed, and commercialized the world's first end-to-end digital industrial



manufacturing system, announced today that it has completed a Series D equity financing totaling $230 million. The round was led by a $100 million investment from Hexagon AB and included participation from new and existing institutional and family office investors.

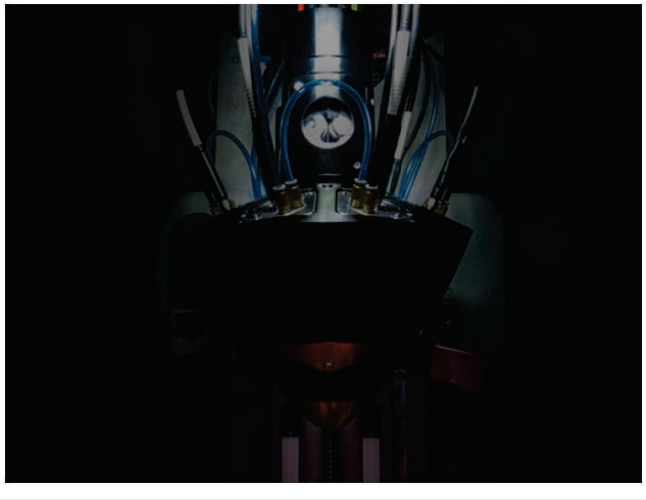
Divergent has developed the Divergent Adaptive Production System ("DAPS™"), an end-to-end system-level replacement for traditional design, manufacturing, and assembly solutions. DAPS is a complete software-hardware production system that leverages in-house developed AI-driven generative design software to computationally engineer structures, novel materials and additive manufacturing to materialize structures, and automated fixtureless assembly to create large multi-part assemblies. Products created using DAPS are superior in performance, lower in cost, rapidly customizable to meet mission and customer-specific requirements, faster to market, and scalable on demand to high volume production.

Divergent uses this revolutionary system to supply the automotive, aerospace and defense industries with next generation products as a certified Tier 1 supplier. It has seven blue-chip automotive customers, including Aston Martin and Mercedes-AMG. Within the aerospace and defense industry, Divergent is actively working with six U.S. government contractors across a diverse range of applications.

"DAPS was created to serve as the foundation for a global system of regional manufacturing facilities that combine and fully exploit supercomputing, AI, robotics and additive manufacturing in a novel way," said Kevin Czinger, Founder, Lead Inventor and CEO. "We now have entered the '4D Age' of fully digitized design-manufacturing-assembly as a service, dematerialized products using and requiring less material and energy, distributed regional production, and democratized access to the tools, data and production assets necessary for innovation in our human-built world."

Lukas Czinger, President and Chief Operating Officer added, "DAPS allows customers to develop higher performing products on faster timelines and with zero design-specific capex, freeing manufacturers from the burdens of legacy design decisions. Divergent is on a mission to rebuild the American industrial base with a truly transformational manufacturing technology."

Meltio Exceeds 300 Systems Sold and Covers the Needs of Manufacturing and Repairing Industrial Metal Parts With Its Unique Wire-Laser Metal 3D Printing Technology



Meltio, a disruptive wire-laser metal deposition technology manufacturer, is in luck time. Why ? The Spanish multinational dedicated to the development of its unique and patented wire-laser metal 3D printing technology for the worldwide sector has just celebrated a very remarkable ephemeris: Meltio has exceeded 300 systems sold worldwide.

The mission of the metal AM company is to provide to the all industries around the world the ultimate wire-laser metal additive manufacturing unique technology developed by Meltio to create and repair reliable and high dense metal parts (stainless steels, titanium, nickel, inconel and many other materials).

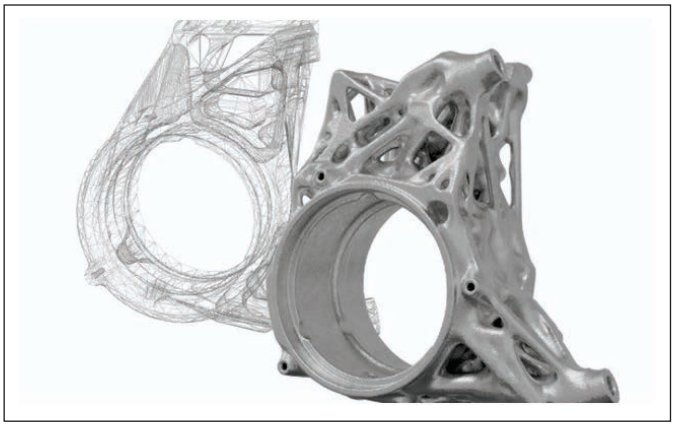
Meltio is revolutionizing the way of manufacturing and repairing metal parts achieving very reliable results and extraordinarily dense parts with our additive manufacturing technology. Industries such as automotive, aerospace, oil and gas, mining, research centers, universities and others in more than 60 countries already enjoy Meltio's solutions.

Ángel Llavero, CEO of Meltio, says: "This milestone of exceeding 300 Meltio systems sold worldwide confirms that the industry is embracing our metal 3D printing solutions for manufacturing and repairing metal parts. It is a recognition of the efforts of the entire Meltio team and a confirmation that we are on the right path of innovation to offer the market new Meltio solutions that respond to their production needs, flexibility and reliability in industrial manufacturing processes".

At Meltio we are covering the needs of industries around the world in their quest for cost reduction and increased reliability in their manufacturing processes. With the installation and adoption of Meltio's metal AM solutions, industries gain in flexibility and automation of their industrial processes by being able to repair and manufacture metal parts in a user-friendly environment and with availability and access to our technology 7/7 24 hours a day, a great leap from conventional manufacturing processes.

Cognitive Design Systems Successfully Raises €2 Million in Funding

Cognitive Design Systems, an innovative company dedicated to making 3D models manufacturable, is thrilled to announce that it has secured €2 million in funding. The funds raised will be boosting the technological development of CDS's platform that had



begun in 2021, additionally CDS will also look at expanding their geographic footprint and salesforce in Europe and the United States.

CDS has rapidly gained attention in the field of generative design and within the 3D printing community. Known for their Design for Additive Manufacturing (DfAM) software solution, "Cognitive Additive," which specializes in analyzing the cost, feasibility, and sustainability of 3D-printed parts, CDS has also integrated various modules into a range of platforms. These platforms include Synera, a low-code engineering platform, and GrabCAD Print, a software solution platform offered by Stratasys. This round will speed up the company's growth and enhance the integration of their technologies with major CAD platforms.

The €2 million round was made possible through the support of Iron Hands Capital, DAA Capital Partners and SpaceFounders France.

Vincent Ung, CDS Co-founder and COO states: "The team and I would like to extend gratitude to our investors and supporters who have shown unwavering belief in our vision and joined us on this incredible adventure. We believe that modern engineering requires innovative solution, and that the key to product development is to consistently include the manufacturing factors as part of design."

Florent Gastaud, Managing Partner at IRON HANDS CAPITAL, added: "We are delighted to support CDS and its management team in the next stage of its growth

story. Thanks to its strong expertise, solid platform, innovative and differentiated product offering, CDS will emerge as one of the next leading manufacturable design platform in generative design. The company is now ready to capture the attractive opportunities of the European and the United States market to growing at an accelerated pace."

Bertrand Mueller, Founding Partner at DAA Capital Partners said: "We believe that the automatization of engineering tasks and the prediction of the manufacturability and costs of any product designed in 3D is a global megatrend in the industry. CDS is uniquely positioned to benefit from this trend thanks to its state-of-the-art modeling technology. "

HP Partners with INDO-MIM to Advance Metal Additive Manufacturing

The collaboration marks a significant step in the journey from adoption to scale for HP's Metal Additive Manufacturing Technology

At Formnext on 7th November 2023, HP Inc announced a strategic partnership with INDO-MIM (Indo-MIM Private Limited), one of the world largest companies in the Metal Injection Molding (MIM) industry and an emerging player in the additive manufacturing powder industry. This collaboration marks a significant step toward advancing metal additive manufacturing technology and expanding its applications in various industries. INDO-MIM has initially invested in three cutting-edge HP Metal Jet S100 printers as part of this collaboration, strengthening their commitment to advancing additive manufacturing globally.

Two of three printers will be stationed at INDO-MIM's Bangalore, India facility. One of them will focus on new material development, while the other will be driving application development and cater to customers in the Middle East, India and the rest of the Asia-Pacific region. The third unit will be based in Texas, USA, reinforcing INDO-MIM's commitment to providing localized support for North American clients and expanding their production capabilities.

"We are proud to partner with INDO-MIM to create new possibilities for their customers leveraging our S100 solution and metals additive manufacturing capabilities. We are thrilled to work with INDO-MIM to drive new metals applications, expand material possibilities and increase precision and productivity," stated Savi Baveja, President of Personalization & 3D Printing and Chief Incubation Officer, HP Inc. "We share a common purpose to accelerate innovation, grow adoption and scale breakthrough applications."

Krishna Chivukula Jr, CEO at Indo-MIM also expressed his excitement about the collaboration, noting, "Our partnership with HP signifies a milestone in our journey to provide cutting-edge production ready 3D metal binder jet solutions to our customers. The acquisition of HP's Metal Jet S100 printers equips us with the latest technology, enabling us to meet the growing demands of our customers with efficiency and precision, as well as expand the library of materials qualified on the HP printer platform."

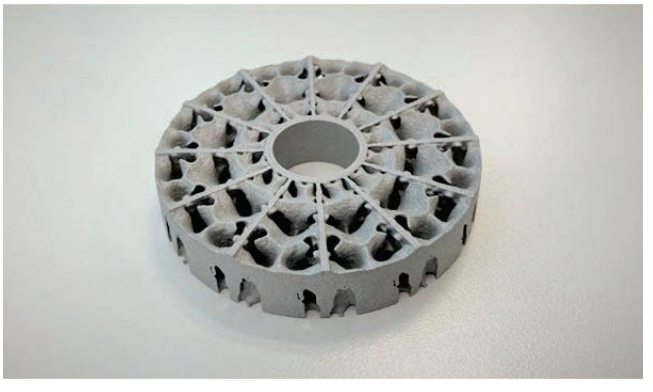
HP and INDO-MIM are not only expanding their additive manufacturing capabilities but are working together to qualify new HP Metal Jet materials like M2 tool steel and others that will unlock a broad array of capabilities including improved properties and dimensional tolerances.

Additionally, INDO-MIM will leverage HP's Process Development software to deliver innovative solutions for speed, scalability, and adaptability. Mukund Nagaraj, Head of Additive Manufacturing, praised the software, stating, "The HP Process Development software is very impressive for managing application development

workflows, while the newly released Digital Sintering software will help INDO-MIM simulate and speed up the process to reach production quality parts in fewer iterations."

Both HP and INDO-MIM are committed to advancing innovative technology and sustainable manufacturing. Together, these leading companies are well-positioned to unleash the full potential of metal additive manufacturing, helping transform markets including aerospace, automotive, consumer electronics, healthcare, industrial, and more.

Ricoh and Siemens collaborate to realize the industrial aluminum Binder Jetting process for mass production



High efficiency air-cooling heatsink created by RICOH's aluminum Binder Jet Technology (BJT) system (Image credit: @Ricoh)

Ricoh and Siemens start collaboration to develop the solution for aluminum Binder Jetting Technology for mass production.

As the first step of the collaboration, Ricoh has implemented Siemens' Additive Manufacturing Network to build a full digital process to optimize its internal process and machine management for aluminum binder jetting technology – from print job preparation, through manufacture, to delivery of components.

Ricoh also aims to leverage the Additive Manufacturing Network capabilities to digitally transform its process service provision to a wide spectrum of industrial additive manufacturing focused customers.

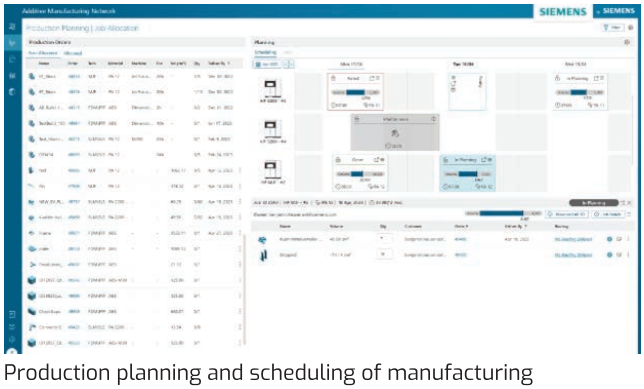
Siemens Digital Industries Software has today announced that Ricoh have begun a collaboration to realize the industrial aluminum Binder Jetting (BJT) solution for mass production. Ricoh is leveraging Siemens' Additive Manufacturing Network capabilities to maximize the efficiency of the process and to achieve the scale required to take advantage of BJT in an industrial setting.

Additionally, Ricoh is implementing Siemens' Additive Manufacturing Network to optimize the aluminum BJT workflow for production preparation, planning, scheduling, and production management with less effort. Ricoh has also implemented Siemens' Brownfield Connectivity and has begun collecting and storing information on each process necessary for quality stabilization and production control. Siemens will continue to provide Ricoh with solutions optimized for the aluminum BJT workflow, and both companies aim for early commercialization of these technologies.
Ricoh's proprietary Binder Jetting Technology applies the company's inkjet printing technology and expertise to enable the production of metal parts with more complex shapes that would not be possible with conventional metal processing methods such as machining and casting. In the process of BJT, the aluminum-alloy powder is spread out over the modeling area and then solidified with a specially formulated binder to shape the part. The same process continues layer-by-layer-by-layer until completing shaping the whole part. After the process, the 'green-body' part is sintered in a furnace to create a densified, end-use component that can be used as is or enter a downstream post-processing chain.

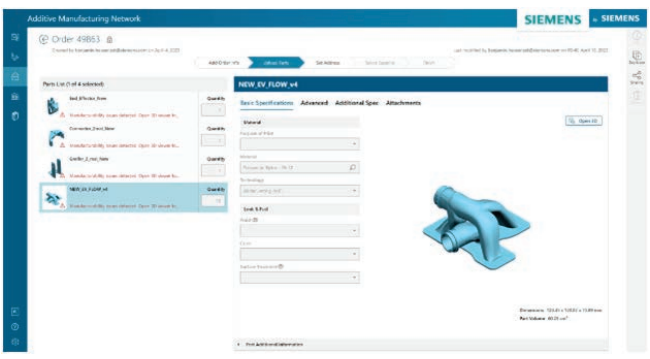
Ricoh has positioned the "realization of a zero-carbon society" as one of its material issues. Ricoh aims to achieve zero GHG emissions throughout its entire value chain, enabling customers to develop highly energy-efficient products by using Ricoh's 3D printers, thereby contributing to the realization of a zero-carbon society.
"The production of aluminum parts is a holy grail for the

additive industry and we're delighted that Ricoh has chosen Siemens' Additive Manufacturing Network capabilities from the Siemens Xcelerator portfolio of industry software to help them commercialize a much sought-after process," said Zvi Feuer, Senior Vice President, Digital Manufacturing Software, Siemens Digital Industries Software. "Our collaboration with Ricoh will apply its expertise in additive manufacturing with our knowledge and experience in delivering additive-specific operations management technology across a wide spectrum of industries – from order capture, production planning, and manufacturing to part delivery transaction closure. Together, Siemens and Ricoh are working to deliver repeatability and consistency at the scale needed to truly take advantage of using robust and repeatable aluminum additively manufactured parts in the commercial world."

Tokutaro Fukushima, General Manager of Additive Manufacturing Business Center, Ricoh Futures Business Unit, Ricoh Company, Ltd., said, "Ricoh will enable our customers to manufacture innovative aluminum components that have never been produced before by any process and will work with them to realize new customer value in the area of electrification of EVs and other forms of mobility. By combining Siemens' powerful solutions and knowledge with Ricoh's aluminum BJT, we will be able to provide our customers with highly reliable and practical systems for mass production applications. We hope to promote electrification together with our customers and contribute to solving social issues such as realizing a zero-carbon society."



Production planning and scheduling of manufacturing using Siemens' Additive Manufacturing Network (Image credit: Siemens Digital Industries Software)



The Siemens' Additive Manufacturing Network order submission portal (Image credit: Siemens Digital Industries Software)

Metal Binder Jetting Technology for manufacturing innovative aluminum parts contributes to weight reduction and improved heat exchange performance of aluminum parts by realizing shapes that cannot be produced with existing processing technologies. The binder jetting method saves time and resources due to its high productivity and the ability to reuse unused materials. Ricoh's industrial inkjet printhead technology, developed over many years, enables stable manufacturing of parts with complex shapes and is capable of processing aluminum alloy, a widely used material for metal parts.

Progreso 3D-Printed a House That Can Withstand a 9.0 Magnitude Earthquake

By Oceane Duboust Published on 25/10/2023 - 17:43

Progreso, a leader in Central and South America's cement industry, has through its corporate accelerator Progreso X inaugurated Guatemala's first-ever 3D printed building. The milestone was achieved in collaboration with Danish 3DCP Group utilizing COBOD

International's BOD2 construction 3D printer, the best-selling 3D construction printer in the world, and already employed widely in the US, Canada and various Latin American countries, including Mexico.

Highlights

- Progreso, a leader in Central and South America's cement industry, recently inaugurated Guatemala's first 3D printed house.
- The small organically shaped house of 49 m2 (527 SF) was made using a printer from COBOD International and combines this modern construction technique with the traditional palm leaves rancho-roof type ideal for seismic regions.
- The pioneering project was completed in just 26 printing hours over seven days with a key goal of verifying the structural integrity of 3D construction printing in a seismic-prone region.

The project has successfully taken steps to validate the structural viability of 3D construction printing in a seismic-prone region. The project, featuring three-meter (nine feet) high 3D printed walls, was completed in just 26 printing hours over seven days.

Due to the use of 3D printing, the house features highly organic-shaped walls that would otherwise be extremely expensive, even unfeasible to complete with concrete blocks, the region's predominant building material.

The 3D printed concrete walls are complemented by a "Rancho" type palm leaves roof. This roof type has been used for generations in Latin America, as it is inexpensive, provides thermal comfort and is well-suited for seismic regions due to the flexible and lightweight material.

The inside of the 3D printed house in Guatemala clearly showing the combination of a modern building technique with generations old type of roof structure.

Plinio Estuardo Herrera, Manager of Concrete R&D at Progreso, commented on the project inauguration: "With immense satisfaction, we completed this unique project using 3D printing technology, once deemed distant. Progreso's enduring spirit of innovation led us to explore new methods, culminating in a collaboratively designed building featuring a sustainable "rancho" roof, ensuring natural cooling in seismic regions. This achievement, a testament to our teamwork, harmoniously blends advanced technology with local traditions, thanks to the unwavering support of 3DCP Group and COBOD."

The project, representing Guatemala's entry into the world of advanced global construction methods, was achieved through a partnership with Denmark's 3DCP Group, known for among other the 3D printing of the first school in Ukraine as part of the re-construction of the country. The first house in Guatemala will not be the only project the partners are doing together.

Philip Lund-Nielsen, Co-Founder and Head of Americas of COBOD, applauded the achievement, stating from his company's base in Miami, FL: "The completion of Guatemala's first 3D printed house living up to all seismic requirements marks a significant milestone for construction 3D printing in Latin America. The region has adopted 3D construction printing slower than others, but the interest is growing rapidly. We expect interesting new developments to happen shortly, including in Mexico, especially now that successful steps have been taken to verify the suitability of the printing technology in a seismic region.

Research and Development News

Harvard Researchers Reverse-engineer Jackson Pollock with a new 3D-printing technique

Liquid coiling was extensively utilized by Jackson Pollock in his drip paintings (left). Using reinforcement learning, the agent can learn to draw parts of Pollock's Figure, 1948 (center). Credit: Soft Math Lab/Harvard SEAS

Can a machine be trained to paint like Jackson Pollock? More specifically, can 3D printing harness Pollock's distinctive techniques to quickly and accurately print complex shapes?

"I wanted to know, can one replicate Jackson Pollock, and reverse engineer what he did?" said L. Mahadevan, the Lola England de Valpine Professor of Applied Mathematics at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), and Professor of Organismic and Evolutionary Biology, and of Physics in the Faculty of Arts and Sciences (FAS).

Mahadevan and his team combined physics and machine learning to develop a new 3D-printing technique that can quickly create complex physical patterns—including replicating a segment of a Pollock painting—by leveraging the same natural fluid instability that Pollock used in his work.

The research is published in Soft Matter.

3D and 4D printing has revolutionized manufacturing but the process is still painstakingly slow.

The issue, as it usually is, is physics. Liquid inks are bound by the rules of fluid dynamics, which means when they fall from a height, they become unstable, folding and coiling in on themselves. You can observe this at home by drizzling honey on a piece of toast.

More than two decades ago, Mahadevan provided a simple physical explanation of this process, and later suggested how Pollock could have intuitively used these ideas to paint from a distance.

Reinforcement-learning controlled cursive handwriting using silicone oil. Credit: Soft Math Group/Harvard SEAS Today, most 3D and 4D printing techniques place the print nozzle millimeters from the surface, all but eliminating the dynamic instability of the liquid stream. But Mahadevan has a motto: Use the physics, instead of avoiding it.

"We wanted to develop a technique that could take advantage of the folding and coiling instabilities, rather than avoid them," said Gaurav Chaudhary, a former postdoctoral fellow at SEAS and first author of the paper.

Pollock composed his famous drip paintings by placing a canvas on the floor and drizzling, pouring, dripping and splashing paint onto it from above. To the untrained eye, his technique may seem haphazard, but Pollock always claimed he had complete control over the flow of the paint.

Dubbed "action painting," Pollock drew in the space above the canvas—creating shapes in the air that would fall to the canvas below.

"If you look at traditional 3D printers, you supply them a path from point A to point B and the nozzle deposits ink along that specified path," said Chaudhary. "But Pollock's approach of throwing paint from a height meant that even if his hand was moving in a specific trajectory, the paint didn't follow that trajectory because of the

acceleration gained from gravity. A small motion could result in a large splatter of paint. Using this technique, you can print larger lengths than you can move because you gain this free acceleration from gravity."

The question was, how to control it?

To learn how to manipulate the nozzle to print at a distance and control fluid coiling, Mahadevan and Chaudhary, along with co-authors Stephanie Christ, a former student in Mahadevan's Soft Math Lab, and A. John Hart, Professor of Mechanical Engineering at MIT, combined the physics of coiling with deep reinforcement learning, which is an algorithmic approach to improving performance iteratively. Mahadevan and his team used techniques developed by Petros Koumoutsakos, the Herbert S. Winokur, Jr. Professor of Computing in Science and Engineering at SEAS.

A 3D-printed cursive "Cambridge" printed using reinforcement learning. Credit: Soft Math Lab/Harvard SEAS

"With deep reinforcement learning, the model can learn from its mistakes and get more and more accurate with each trial," said Chaudhary.

Using this technique, the researchers printed a series of complex shapes, painting like Pollock and even decorating a cookie with chocolate syrup.

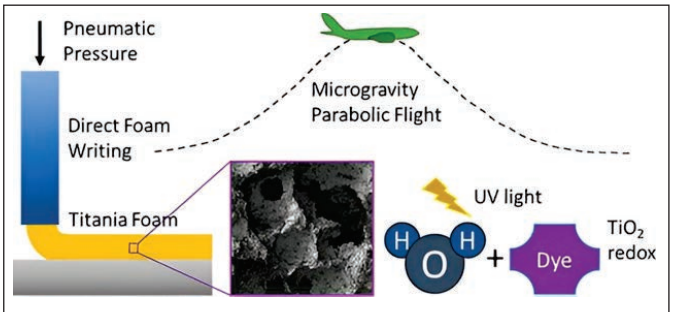
The researchers used simple fluids for this research, but the approach could be expanded to include more complex fluids, such as liquid polymers, pastes and various types of foods.

"Harnessing physical processes for functional outcomes is both a hallmark of intelligent behavior, and at the heart of engineering design. This little example suggests, once again, that understanding the evolution of the first might help us be better at the second," said Mahadevan.

As the research continues, there is no telling where Mahadevan may look for inspiration next.

"When you're in Maha's lab, nothing is off the table," said Chaudhary.

West Virginia University team explores 3D printing in microgravity



Graphical Abstract. Credit: ACS Applied Materials & Interfaces (2023). DOI: 10.1021/acsami.3c09658

Research from West Virginia University students and faculty into how 3D printing works in a weightless environment aims to support long-term exploration and habitation on spaceships, the moon or Mars.

Extended missions in outer space require the manufacture of crucial materials and equipment onsite, rather than transporting those items from Earth. Members of the Microgravity Research Team said they believe 3D printing is the way to make that happen.

The team's recent experiments focused on how a weightless microgravity environment affects 3D printing using titania foam, a material with potential applications ranging from UV blocking to water purification. ACS Applied Materials and Interfaces published their findings.

"A spacecraft can't carry infinite resources, so you have to maintain and recycle what you have and 3D printing enables that," said lead author Jacob Cordonier, a doctoral student in mechanical and aerospace engineering at the WVU Benjamin M. Statler College of Engineering and Mineral Resources. "You can print only what you need, reducing waste. Our study looked at whether a 3D-printed titanium dioxide foam could protect against ultraviolet radiation in outer space and purify water."

"The research also allows us to see gravity's role in how the foam comes out of the 3D printer nozzle and spreads onto a substrate. We've seen differences in the filament shape when printed in microgravity compared to Earth gravity. And by changing additional variables in the printing process, such as writing speed and extrusion pressure, we're able to paint a clearer image of how all these parameters interact to tune the shape of the filament."

Cordonier's co-authors include current and former undergraduate students Kyleigh Anderson, Ronan Butts, Ross O'Hara, Renee Garneau and Nathanael Wimer. Also contributing to the paper were John Kuhlman, professor emeritus, and Konstantinos Sierros, associate professor and associate chair for research in the Department of Mechanical and Aerospace Engineering.

Sierros has overseen the Microgravity Research Team's titania foam studies since 2016. The work now happens in his WVU labs but originally required taking a ride on a Boeing 727. There, students printed lines of foam onto glass slides during 20-second periods of weightlessness when the jet was at the top of its parabolic flight path.

"Transporting even a kilogram of material in space is expensive and storage is limited, so we're looking into what is called 'in-situ resource utilization,'" Sierros said. "We know the moon contains deposits of minerals very similar to the titanium dioxide used to make our foam, so the idea is you don't have to transport equipment from here to space because we can mine those resources on the moon and print the equipment that's necessary for a mission."

Necessary equipment includes shields against ultraviolet light, which poses a threat to astronauts, electronics and other space assets.

"On Earth, our atmosphere blocks a significant part of UV light—though not all of it, which is why we get sunburned," Cordonier said. "In space or on the moon, there's nothing to mitigate it besides your spacesuit or whatever coating is on your spacecraft or habitat."

To measure titania foam's effectiveness at blocking UV waves, "we would shine light ranging from the ultraviolet wavelengths up to the visible light spectrum," he explained. "We measured how much light was getting through the titania foam film we had printed, how much got reflected back and how much was absorbed by the sample. We showed the film blocks almost all the UV light hitting the sample and very little visible light gets through. Even at only 200 microns thick, our material is effective at blocking UV radiation."

Cordonier said the foam also demonstrated photocatalytic properties, meaning that it can use light to promote chemical reactions that can do things like purify air or water.

Team member Butts, an undergraduate from Wheeling, led experiments in contact angle testing to analyze how changes in temperature affected the foam's surface energy. Butts called the research "a different type of challenge that students don't always get to experience," and said he especially valued the engagement component.

"Our team gets to do a lot of outreach with young students like the Scouts through the Merit Badge University at WVU. We get to show them what we do here as a way to say, 'Hey, this is something you could do, too,'" Butts said.

According to Sierros, "We're trying to integrate research

into student careers at an early point. We have a student subgroup that's purely hardware and they make the 3D printers. We have students leading materials development, automation, data analysis. The undergraduates who have been doing this work with the support of two very competitive NASA grants are participating in the whole research process. They have published peer-reviewed scientific articles and presented at conferences."

Garneau, a student researcher from Winchester, Virginia, said her dream is for their 3D printer—custom designed to be compact and automated—to take a six-month trip to the International Space Station. That would enable more extensive monitoring of the printing process than was possible during the 20-second freefalls.

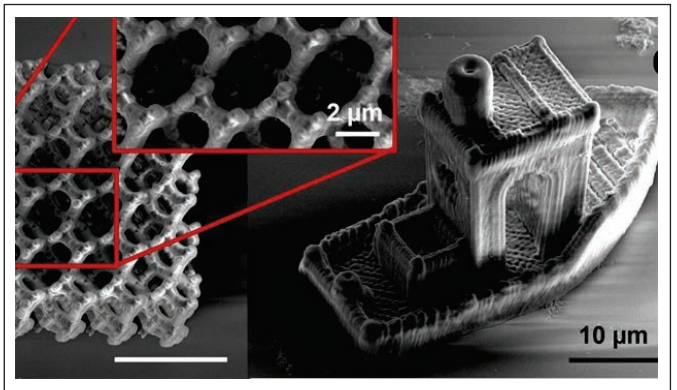
"This was an amazing experience," Garneau said. "It was the first time I participated in a research project that didn't have predetermined results like what I have experienced in research-based classes. It was really rewarding to analyze the data and come to conclusions that weren't based on fixed expectations.

"Our approach can help extend space exploration, allowing astronauts to use resources they already have available to them without necessitating a resupply mission."

Researchers demonstrate new 3D printing technique for quantum sensors

Quantum sensing is an emerging field that holds great promise, but building the crystal substrate for these nanoscale sensors has proved challenging. Now, Berkeley researchers have developed a novel fabrication method to structure quantum sensing particles into complex 3D configurations that can accurately detect changes in temperature and magnetic fields in microscopic environments.

As reported in the journal Nano Letters, researchers used additive manufacturing methods to produce highly customizable 3D structures that can host tiny



A new 3D printing technique for quantum sensors enables researchers to embed nitrogen vacancy centers in microscale 3D structures with complex geometries, including a nanoscale "3DBenchy," a test model that resembles a tugboat. (Image courtesy of Biomolecular Nanotechnology Center of the California Institute for Quantitative Biosciences, UC Berkeley)

diamonds containing quantum sensing elements. These printable quantum sensors enable sensitive measurements at room temperature, which may open the door to transformative applications for materials science, biology and chemistry.

"Our work showcases the potential for integrating quantum sensors with advanced additive manufacturing techniques, which enable us to create new designs that are not otherwise possible," said Brian Blankenship, co-lead author of the study and a graduate student in the Department of Mechanical Engineering. "In a couple of years, this technology might be used to incorporate sensors into microfluidics, electronics and biological systems — and open new avenues for the widespread utilization of quantum sensors for other applications that we haven't even thought about yet."

Co-principal investigator Costas Grigoropoulos, professor of mechanical engineering, added that because this new fabrication technique enables customization, structures can be precisely designed with the desired properties. "These architected materials are optimized to provide a tailored mechanical response," said Grigoropoulos. "They combine sensing as well as actuation functionalities for applications in structural materials, tissue engineering and opto-mechanical systems."

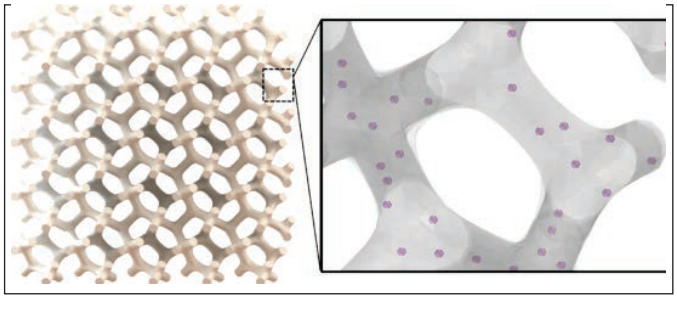
Quantum sensors use the properties of atoms and light to measure minute changes in magnetic and electric fields, strain and temperature. Today they are used in some of the most precise clocks on Earth that power GPS systems, and there is strong interest in applying these sensors in other areas, including neuroscience.

But taking quantum sensors out of pristine lab conditions is difficult, according to Grigoropoulos. "Many platforms for quantum sensing require extremely cold temperatures — hundreds of degrees below freezing — in order to function correctly," he said. "In addition, these materials often need to be very clean and perfectly crystalline, which can prohibit their use in many practical applications."

To tackle this problem, the researchers employed additive manufacturing techniques to structure quantum sensing particles, known as nitrogen vacancy centers, into 3D configurations. These nitrogen vacancy centers occur when a single carbon atom inside diamond is replaced by a nitrogen atom, and an adjacent carbon atom is empty. Nitrogen vacancy centers are unique because they work surprisingly well at room temperature and keep their quantum properties even when they are particles.

"Our approach overcomes the challenges associated with structuring single-crystal substrates, and these nitrogen vacancy centers can work reliably at room temperature," said Blankenship. "We demonstrated that by using a modified microscope, we could take precise measurements of temperature and magnetic field measurements inside of these structures."

Nitrogen vacancy centers embedded in microscale 3D structures with complex geometries. These structures can be optically imaged to measure temperature and magnetic field inside of them. (Image courtesy of Brian Blankenship)



According to Blankenship, the researchers are optimistic that this advancement will pave the way to new possibilities for quantum sensing.

"This technique now gives us the ability to print sensing elements into existing microfluidic chips, on top of advanced semiconductor devices and even cellular scaffolding, while providing advanced diagnostics for these systems," he said. "And though our paper focuses on measuring temperature and magnetic fields, we believe this work can be extended to take other types of measurements as well."

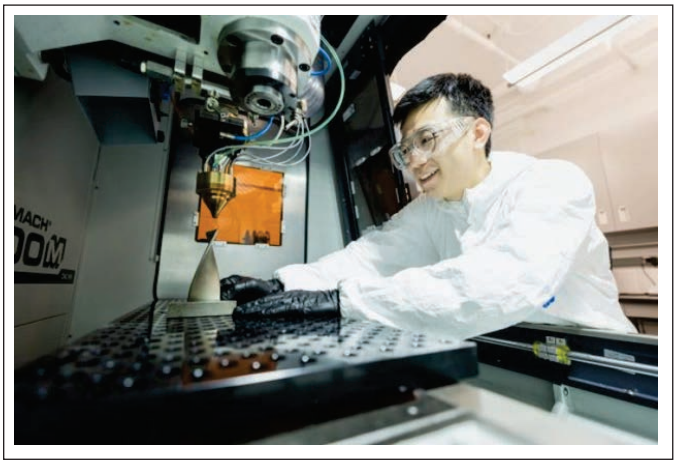
Grigoropoulos and Ashok Ajoy, assistant professor of chemistry, served as co-principal investigators of the study. Co-lead authors include Blankenship and Zachary Jones, a postdoctoral researcher in Ajoy's lab and at Lawrence Berkeley National Laboratory. Co-authors are Naichen Zhao, Runxuan Li, Erin Suh and Alan Chen, all from the Department of Mechanical Engineering, and Harpreet Singh and Adrisha Sarkar from the Department of Chemistry.

Work done at the Laser Thermal Laboratory, a research group affiliated with the Department of Mechanical Engineering , is funded by the National Science Foundation. The lab's main objective for this project was to design and fabricate complex hybrid materials using multiphoton lithography.

This machine learning method aims to speed up the design of next-generation biomedical implants and aerospace materials

One of the bigger challenges in designing advanced structural materials, such as bone-like medical implants and stronger parts for more fuel-efficient aircraft, is the length of time it takes for research to move from laboratories to industrial applications.

"Designing microstructures is a key step in materials



development," says Professor Yu Zou (MSE), whose lab group is using machine learning to accelerate the discovery of new structural materials.

"But traditional materials design, which is based on experiments or simulation methods, could take years — even decades — to identify the right microstructure."

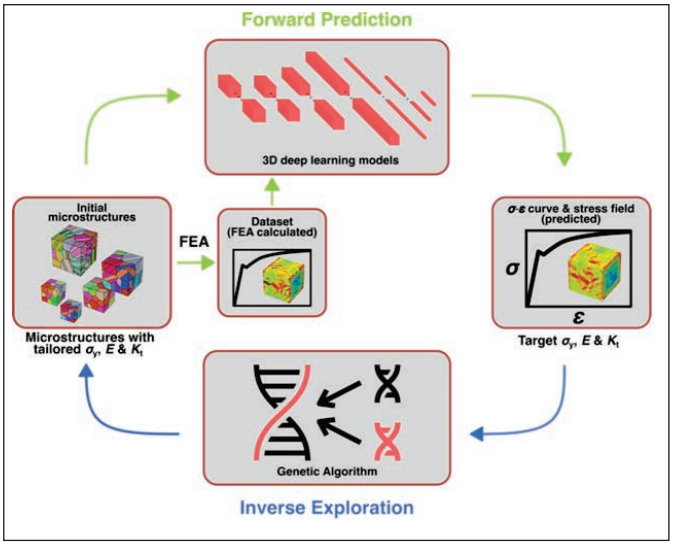
In a new paper, published in Materials Today, Zou's team describes a novel end-to-end framework used to tailor the microstructure of Ti-6Al-4V, the most widely used titanium alloy in the aerospace and biomedical industries.

"This work could enable material scientists and engineers to discover microstructures at speeds unseen before, by simply inputting their desired mechanical properties into the framework," says Xiao Shang (MSE PhD candidate), the lead author of the paper.

The researchers began by training two deep-learning models to accurately predict material properties from their microstructures. They then integrated a genetic algorithm with the deep-learning models to close the materials-by-design loop, which allows the framework to design optimal material microstructures with target mechanical properties.

"In less than eight hours, we identified titanium alloy microstructures that showed both the high strength and high stiffness needed to strengthen the structural components of airplanes," says Shang.

"We also designed titanium alloys with the same chemical compositions as the former but with different microstructures that are about 15% more compliant for biomedical implants compatible with human bones."



A schematic demonstration of the materials design framework. Within the framework, deep learning models are first established to predict a material's mechanical properties (forward prediction), after which the genetic algorithm is used to efficiently search for the optimal material microstructure for given target material properties (inverse exploration). (Image: Laboratory for Extreme Mechanics and Additive Manufacturing)

The researchers did face some bottlenecks during the development of their deep learning models. They had to generate their own dataset of close to 6,000 different microstructures through simulation, and they were able to acquire the massive computing powers that made the dataset generation possible by working with super computers at the Digital Research Alliance of Canada.

"We constantly ran into situations where our selected deep learning models and/or optimization algorithms just wouldn't work as well as we expected," says Shang.

"But we were patient and held on to our research plan,

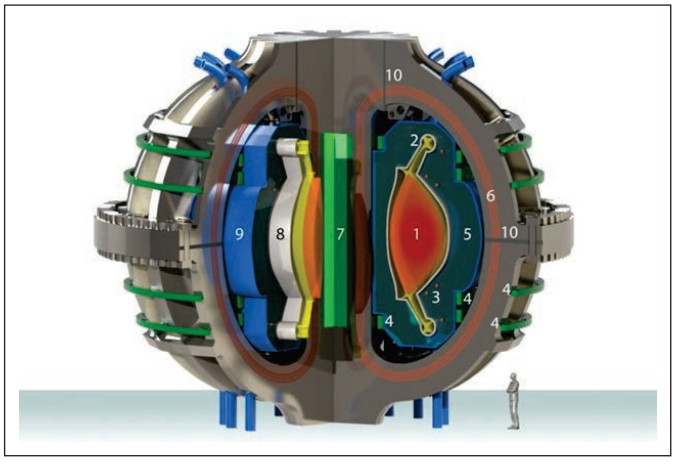
while actively searching for new approaches to make the models work."

This past summer, the research, which is supported by the Data Sciences Institute and Centre for Analytics and Artificial Intelligence Engineering at U of T, won a Poster Prize at the 2023 Accelerate Conference.

"Looking forward, we want to further optimize and improve additive manufacturing technology so that they can continue to advance this new framework," says Tianyi Lyu (MSE PhD candidate), who along with Jiahui Zhang (MSE PhD candidate), is a co-author of the new paper — both working on metal additive manufacturing. "We are advancing the quality and reliability of metal additive manufacturing, unleashing its potentials to locally tailor the material microstructure during printing," adds Zou.

"For example, with traditional technology, it is close to impossible to tailor biomedical materials for different patients. But we want to enable the future of personalized biomedical implants by making it possible to print the shape and mechanical properties that match a patient's needs in only a few days."

Printing a new approach to fusion power plant materials



MIT PhD student Alexander O'Brien is working to deliver the next generation of fusion devices through research on additive manufacturing of metal-ceramic composites.

When Alexander O'Brien sent in his application for graduate school at MIT's Department of Nuclear Science and Engineering, he had a germ of a research idea already brewing. So when he received a phone call from Professor Mingda Li, he shared it: The student from Arkansas wanted to explore the design of materials that could hold nuclear reactors together.

Li listened to him patiently and then said, "I think you'd be a really good fit for Professor Ju Li," O'Brien remembers. Ju Li, the Battelle Energy Alliance Professor in Nuclear Engineering, had wanted to explore 3D printing for nuclear reactors and O'Brien seemed like the right candidate. "At that moment I decided to go to MIT if they accepted me," O'Brien remembers.

And they did.

Under the advisement of Ju Li, the fourth-year doctoral student now explores 3D printing of ceramic-metal composites, materials that can be used to construct fusion power plants.

An early interest in the sciences

Growing up in Springdale, Arkansas as a self-described "band nerd," O'Brien was particularly interested in chemistry and physics. It was one thing to mix baking soda and vinegar to make a "volcano" and quite another to understand why that was happening. "I just enjoyed understanding things on a deeper level and being able to figure out how the world works," he says.

At the same time, it was difficult to ignore the economics of energy playing out in his own backyard. When Arkansas, a place that had hardly ever seen earthquakes, started registering them in the wake of fracking in neighboring Oklahoma, it was "like a lightbulb moment" for O'Brien. "I knew this was going to create problems down the line, I knew there's got to be a better way to do [energy]," he says.

With the idea of energy alternatives simmering on the back burner, O'Brien enrolled for undergraduate studies

at the University of Arkansas. He participated in the school's marching band — "you show up a week before everyone else and there's 400 people who automatically become your friends" — and enjoyed the social environment that a large state school could offer. O'Brien double-majored in chemical engineering and physics and appreciated "the ability to get your hands dirty on machinery to make things work." Deciding to begin exploring his interest in energy alternatives, O'Brien researched transition metal dichalcogenides, coatings of which could catalyze the hydrogen evolution reaction and more easily create hydrogen gas, a green energy alternative.

It was shortly after his sophomore year, however, that O'Brien really found his way in the field of energy alternatives — in nuclear engineering. The American Chemical Society was soliciting student applications for summer study of nuclear chemistry in San Jose, California. O'Brien applied and got accepted. "After years of knowing I wanted to work in green energy but not knowing what that looked like, I very quickly fell in love with [nuclear engineering]," he says. That summer also cemented O'Brien's decision to attend graduate school. "I came away with this idea of 'I need to go to grad school because I need to know more about this,'" he says.

O'Brien especially appreciated an independent project, assigned as part of the summer program: He chose to research nuclear-powered spacecraft. In digging deeper, O'Brien discovered the challenges of powering spacecraft — nuclear was the most viable alternative, but it had to work around extraneous radiation sources in space. Getting to explore national laboratories near San Jose sealed the deal. "I got to visit the National Ignition Facility, which is the big fusion center up there, and just seeing that massive facility entirely designed around this one idea of fusion was kind of mind-blowing to me," O'Brien says.

A fresh blueprint for fusion power plants

O'Brien's current research at MIT's Department of Nuclear Science and Engineering (NSE) is equally mind-blowing.

As the design of new fusion devices kicks into gear, it's becoming increasingly apparent that the materials we have been using just don't hold up to the higher temperatures and radiation levels in operating environments, O'Brien says. Additive manufacturing, another term for 3D printing, "opens up a whole new realm of possibilities for what you can do with metals, which is exactly what you're going to need [to build the next generation of fusion power plants]," he says.

Metals and ceramics by themselves might not do the job of withstanding high temperatures (750 degrees Celsius is the target) and stresses and radiation, but together they might get there. Although such metal matrix composites have been around for decades, they have been impractical for use in reactors because they're "difficult to make with any kind of uniformity and really limited in size scale," O'Brien says. That's because when you try to place ceramic nanoparticles into a pool of molten metal, they're going to fall out in whichever direction they want. "3D printing quickly changes that story entirely, to the point where if you want to add these nanoparticles in very specific regions, you have the capability to do that," O'Brien says.

O'Brien's work, which forms the basis of his doctoral thesis and a research paper in the journal Additive Manufacturing, involves implanting metals with ceramic nanoparticles. The net result is a metal matrix composite that is an ideal candidate for fusion devices, especially for the vacuum vessel component, which must be able to withstand high temperatures, extremely corrosive molten salts, and internal helium gas from nuclear transmutation.

O'Brien's work focuses on nickel superalloys like Inconel 718, which are especially robust candidates because they can withstand higher operating temperatures while retaining strength. Helium embrittlement, where bubbles of helium caused by fusion neutrons lead to weakness and failure, is a problem with Inconel 718, but composites exhibit potential to overcome this challenge.

To create the composites, first a mechanical milling

process coats the ceramic onto the metal particles. The ceramic nanoparticles act as reinforcing strength agents, especially at high temperatures, and make materials last longer. The nanoparticles also absorb helium and radiation defects when uniformly dispersed, which prevent these damage agents from all getting to the grain boundaries.

The composite then goes through a 3D printing process called powder bed fusion (non-nuclear fusion), where a laser passes over a bed of this powder melting it into desired shapes. "By coating these particles with the ceramic and then only melting very specific regions, we keep the ceramics in the areas that we want, and then you can build up and have a uniform structure," O'Brien says.

Printing an exciting future

The 3D printing of nuclear materials exhibits such promise that O'Brien is looking at pursuing the prospect after his doctoral studies. "The concept of these metal matrix composites and how they can enhance material property is really interesting," he says. Scaling it up commercially through a startup company is on his radar.

For now, O'Brien is enjoying research and catching an occasional Broadway show with his wife. While the band nerd doesn't pick up his saxophone much anymore, he does enjoy driving up to New Hampshire and going backpacking. "That's my newfound hobby," O'Brien says, "since I started grad school."

ORNL, NASA Collaborate to Create Prototype Lunar Rover Wheel Through Additive Manufacturing

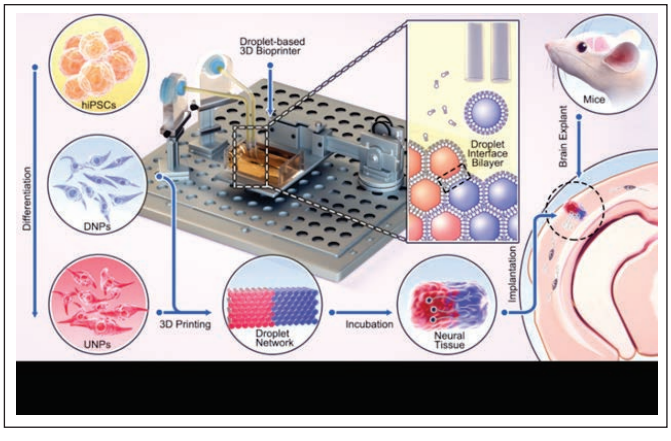
Oak Ridge National Laboratory (ORNL) has teamed up with NASA to produce a lunar rover wheel prototype using a 3D printer. The product highlights the potential role of additive manufacturing in the future of space exploration equipment fabrication, ORNL said Friday.

The nickel alloy prototype was based on NASA's design

Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

of the Volatiles Investigating Polar Exploration Rover, or VIPER, a mobile robot that will be sent to the south pole of the Moon in 2024 to determine the source, distribution and supply of water in the natural satellite. The 3D-printed wheel will not be used in the mission, but will undergo NASA performance testing in comparison with VIPER's traditionally produced wheels. 3D printing was done at ORNL's Manufacturing Demonstration Facility and took less time, cost and manpower to create than conventional processes. The research team was also able to incorporate more complex spoke patterns and locking features thanks to the powder bed printer's two coordinated lasers and a rotating build plate.

Oxford Researchers Develop 3D Printing Method that Shows Promise for Repairing Brain Injuries



Droplets containing human iPSC-derived neural progenitors were 3D-printed to form 2-layer cerebral cortical tissue, which was cultured before implantation

into a mouse brain slice. DNPs: deep-layer neural progenitors; UNPs: upper-layer neural progenitors. Image credit: Yongcheng Jin, University of Oxford.

A breakthrough technique developed by University of Oxford researchers could one day provide tailored repairs for those who suffer brain injuries. The researchers demonstrated for the first time that neural cells can be 3D printed to mimic the architecture of the cerebral cortex. These results have been published today in the journal Nature Communications.

Brain injuries, including those caused by trauma, stroke and surgery for brain tumours, typically result in significant damage to the cerebral cortex (the outer layer of the human brain), leading to difficulties in cognition, movement and communication. For example, each year, around 70 million people globally suffer from traumatic brain injury (TBI), with 5 million of these cases being severe or fatal. Currently, there are no effective treatments for severe brain injuries, leading to serious impacts on quality of life.

This advance marks a significant step towards the fabrication of materials with the full structure and function of natural brain tissues. The work will provide a unique opportunity to explore the workings of the human cortex and, in the long term, it will offer hope to individuals who sustain brain injuries.

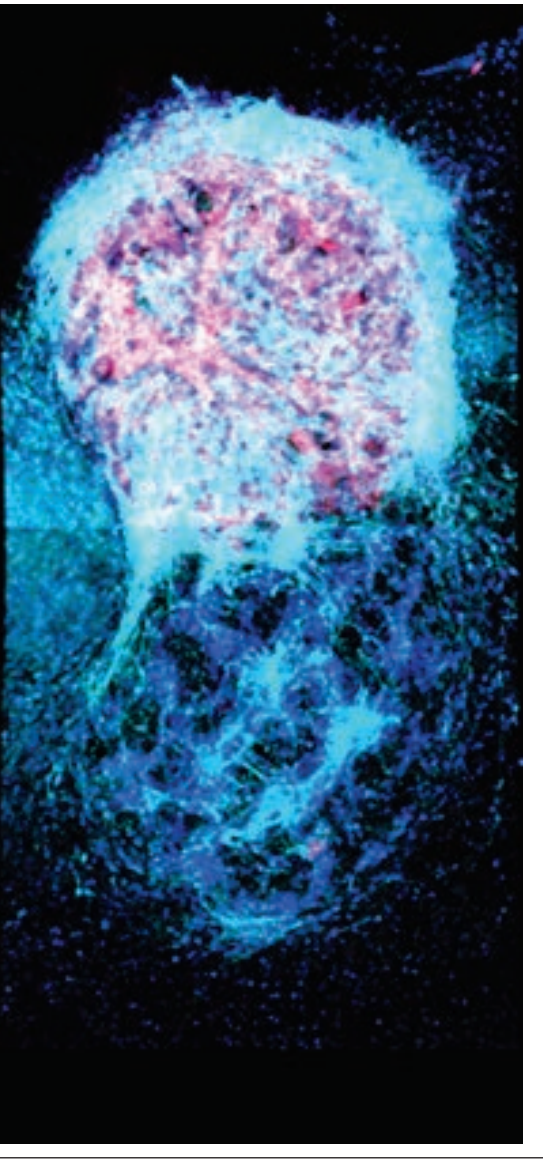
Lead author Dr Yongcheng Jin (Department of Chemistry, University of Oxford)

Tissue regenerative therapies, especially those in which patients are given implants derived from their own stem cells, could be a promising route to treat brain injuries in the future. Up to now, however, there has been no method to ensure that implanted stem cells mimic the architecture of the brain.

In this new study, the University of Oxford researchers fabricated a two-layered brain tissue by 3D printing human neural stem cells. When implanted into mouse brain slices, the cells showed convincing structural and functional integration with the host tissue.

The cortical structure was made from human induced pluripotent stem cells (hiPSCs), which have the potential to produce the cell types found in most human tissues. A key advantage of using hiPSCs for tissue repair is that they can be easily derived from cells harvested from patients themselves, and therefore would not trigger an immune response.

The hiPSCs were differentiated into neural progenitor cells for two different layers of the cerebral cortex, by using specific combinations of growth factors and chemicals. The cells were then suspended in solution to generate two 'bioinks', which were then printed to



produce a two-layered structure. In culture, the printed tissues maintained their layered cellular architecture for weeks, as indicated by the expression of layer-specific biomarkers.

When the printed tissues were implanted into mouse brain slices, they showed strong integration, as demonstrated by the projection of neural processes and the migration of neurons across the implant-host boundary. The implanted cells also showed signalling activity, which correlated with that of the host cells. This indicates that the human and mouse cells were communicating with each other, demonstrating functional as well as structural integration.

3D-printed two-layer cerebral cortical tissue visualised within a mouse brain slice. The implanted neural cells were labelled with fluorescent markers (blue and red in the image). Image credit: Yongcheng Jin, University of Oxford.

The researchers now intend to further refine the droplet printing technique to create complex multi-layered cerebral cortex tissues that more realistically mimic the human brain's architecture. Besides their potential for repairing brain injuries, these engineered tissues might be used in drug evaluation, studies of brain development, and to improve our understanding of the basis of cognition.

The new advance builds on the team's decade-long track record in inventing and patenting 3D printing technologies for synthetic tissues and cultured cells.

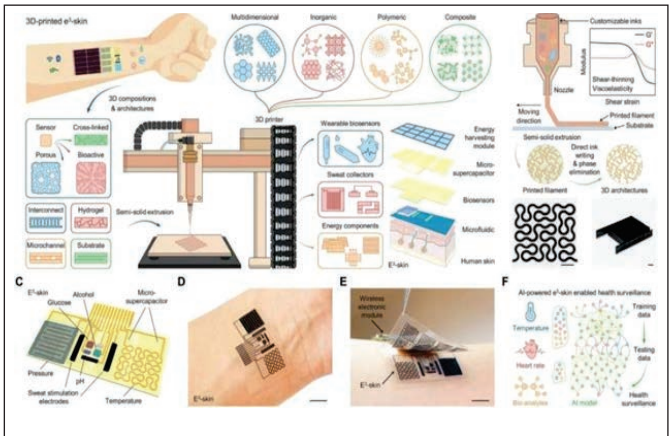
Senior author Dr Linna Zhou (Department of Chemistry, University of Oxford) said: 'Our droplet printing technique provides a means to engineer living 3D tissues with desired architectures, which brings us closer to the creation of personalized implantation treatments for brain injury.'

Senior author Associate Professor Francis Szele (Department of Physiology, Anatomy and Genetics, University of Oxford) added: 'The use of living brain slices creates a powerful platform for interrogating the utility of 3D printing in brain repair. It is a natural bridge between studying 3D printed cortical column development in vitro and their integration into brains in animal models of injury.'

Senior author Professor Zoltán Molnár (Department of Physiology, Anatomy and Genetics, University of Oxford) said: 'Human brain development is a delicate and elaborate process with a complex choreography. It would be naïve to think that we can recreate the entire cellular progression in the laboratory. Nonetheless, our 3D printing project demonstrates substantial progress in controlling the fates and arrangements of human iPSCs to form the basic functional units of the cerebral cortex.'

Senior author Professor Hagan Bayley (Department of Chemistry, University of Oxford) said: 'This futuristic endeavour could only have been achieved by the highly multidisciplinary interactions encouraged by Oxford's Martin School, involving both Oxford's Department of Chemistry and the Department of Physiology, Anatomy and Genetics.'
The study 'Integration of 3D-Printed Cerebral Cortical Tissue into an ex vivo Lesioned Brain Slice' has been published in Nature Communications.

Scientists Develop 3D-Printed Epifluidic Electronic Skin



3D-printed e3-skin with MXene biosensors and solar cell. Credit: Science Advances (2023). DOI: 10.1126/sciadv.adi6492

In a recent study published in Science Advances, researchers from the California Institute of Technology, led by Dr. Wei Gao, have developed a machine learning (ML)–powered 3D-printed epifluidic electronic skin for multimodal health surveillance. This wearable platform enables real-time physical and chemical monitoring of health status.

Wearable health devices have the potential to revolutionize the medical world, offering real-time tracking, personalized treatments, and early diagnosis of diseases.

However, one of the main challenges with these devices is that they don't track data at the molecular level, and their fabrication is challenging. Dr. Gao explained why this served as a motivation for their team.

"Nowadays, there is increasing research interest in personalized health care to revolutionize traditional medical practices. To overcome these challenges, we employ our 3D printing technology to create essential components, such as physical sensors, chemical sensors, microfluidics, and supercapacitors, for our wearable platform," Dr. Gao told Phys.org.

Dr. Gao and his team have done exactly that by realizing the mass-production of a wearable platform called e3-skin, which is 3D printed on customized materials.

e3-skin: A 3D-printed epifluidic electronic skin

The name e3-skin is derived from "epifluidic elastic electronic skin." It is a 3D-printed wearable system that continuously monitors various physiological parameters and predicts behavioral responses.

Dr. Gao explained the various components of e3-skin, saying, "All main components of the wearable platform, including physical sensors, chemical sensors, microfluidics, and energy storage micro-supercapacitors, could be readily prepared via extrusion 3D printing of various functional materials."

What sets the e3-skin apart are the 3D-printed biochemical sensors and microfluidics system. The integration of 3D printing technology is a pivotal aspect of the e3-skin's creation.

3D printing offers precision and customization, allowing researchers to precisely design and manufacture essential components. This streamlined production and enabled the integration of complex structures and materials, including the 3D-printed biochemical sensors and microfluidics.

Dr. Gao further elaborated, "Wearable biochemical sensors could provide crucial health information at molecular levels. When coupled with biophysical sensors, they can provide more comprehensive information about our health state."

Moreover, the use of microfluidics, the science of manipulating and controlling tiny amounts of fluids within small channels or devices, has helped them to analyze the biomarkers in human sweat. Microfluidics can induce sweat automatically through iontophoresis, collect it without the need for strenuous activity, minimize sweat evaporation, and facilitate real-time biochemical analysis with fresh sweat samples.

ML-assisted wearable medical technology

The e3-skin's capabilities extend beyond its hardware components. It integrates ML algorithms, which play a pivotal role in its functionality. But before delving into ML, it's essential to understand the remarkable material that makes the e3-skin possible: Mxene.

MXene, a family of 2D materials, is a versatile material known for its unique properties. Aqueous Ti3C2Tx (MXene) served as the ink to 3D print the interconnects and biophysical sensors in the e3-skin.

The team used the MXene to address a limitation with current wearable systems. In the words of Dr. Gao, "Most current wearable systems rely on batteries, which are rigid, bulky, and insufficient, necessitating frequent replacement."

To address this limitation, the e3-skin integrates a solar cell, harvesting energy from ambient light and efficiently storing it in 3D-printed MXene-based micro-supercapacitors. This innovation enables battery-free, sustainable operation for long-term health monitoring during daily activities.

MXene nanosheets possess properties such as negatively charged surfaces and hydrophilicity, which enable them to disperse and remain stable in water. This allows for precise printing, with MXene filaments having adjustable line widths and the ability to adhere to flexible substrates, like human skin.

Dr. Gao further emphasized, "The printed MXene filaments can form uniform arrays with intricate patterns, enabling the creation of complex structures within the e3-skin."

MXene's versatility extends to temperature sensing, with sensors exhibiting a negative temperature coefficient and wear stability.

For pulse monitoring, MXene, in combination with carbon nanotubes, forms sensors with customizable foam designs, ensuring high sensitivity and durability. Notably, this enables reliable radial pulse monitoring on human subjects.

Furthermore, the e3-skin's capabilities extend to predicting behavioral responses to alcohol consumption, which they demonstrated. Dr. Gao stated, "In our case, we used the e3-skin to collect both sweat alcohol and vital signs (such as heart rate and skin temperature) information, providing more comprehensive insight into behavioral responses."

ML analyzes this data to predict an individual's response time and degree of impairment. Sweat alcohol plays a pivotal role in predicting response time, while heart rate complements sweat alcohol for more accurate impairment prediction.

The future of wearables

e3-skin shows great promise, harvesting the best of ML, materials, and medicine. "e3-skin provides exciting opportunities to advance wearable biosensors toward practical applications in modern health care," highlighted Dr. Gao.

With its continuous monitoring of vital biomarkers and extensive data collection, it has the potential to predict cognitive and behavioral impairments and monitor various health aspects.

The data collected by the e3-skin could enhance personalized health care by allowing early warning, early diagnosis, and timely intervention to maximize health outcomes.

Dr. Gao concluded by stating, "The large sets of data collected by such multimodal wearable devices in daily activities coupled with modern ML algorithms can extract the underlying relationship of the biomarker level with complex health conditions.

"Thereby, it promises to reshape the field of wearable health monitoring and empower data-driven personalized health care."

LLNL, University of California Partner for AI-Driven Additive Manufacturing Research

Lawrence Livermore National Laboratory (LLNL) today announced that Grace Gu, a faculty member in mechanical engineering at the University of California (UC), Berkeley, has been selected as the inaugural recipient of the LLNL Early Career UC Faculty Initiative.
The initiative is a joint endeavor between LLNL's Strategic Deterrence Principal Directorate and UC

national laboratories at the University of California Office of the President, seeking to foster long-term academic partnerships and provide UC faculty members with funding and Lab support for their research. The winning recipient will receive up to $1 million in funding over five years to support an innovative research project in the fields of artificial intelligence (AI) and machine learning (ML).

Gu's winning research proposal, titled "Toward AI-driven additive manufacturing for metal-ceramic composite structures," seeks to develop new composite materials with exceptional properties, particularly in ultra-high-temperature ceramics for energy and defense applications. The project will focus on advancing the capabilities of binder jet 3D printing and optimizing composite feedstock development. This work is strategically aligned with applied data science efforts in materials and advanced manufacturing at LLNL.

With technical support from LLNL research staff, Gu and her team plan to integrate AI algorithms for in-situ monitoring and parameter optimization of 3D printing and create a generative design framework for heterogeneous composite structures. By combining metals and ceramic-based materials, the research focuses on achieving specific mechanical properties that were previously unattainable through traditional manufacturing methods. This ambitious undertaking will employ cutting-edge AI and ML techniques, including neural network surrogate models and deep learning, to achieve its objectives.

"Dr. Gu's research not only pushes the boundaries of materials science but also exemplifies the spirit of our sustained partnership between the University of California, dedicated to propelling innovation and nurturing the next generation of scientific leaders," said Brad Wallin, LLNL deputy director for Strategic Deterrence. "I look forward to the great research and collaborations that will ensue.

"The proposed research promises to advance AI-driven manufacturing technologies while providing opportunities for workforce development, student enrichment and community outreach," Wallin said. "The initiative allows LLNL technical researchers to engage directly with the winning project, further strengthening the collaboration between the two institutions."

Imaging and 3D printing Enhance Teaching of Spinal Anatomy

The use of cross-sectional imaging and 3D printing may enhance the teaching of spinal anatomy in undergraduate medical education, according to a field study published on 2 November in Academic Radiology. A team at the University of Granada in Spain compared the use of conventional approaches with cross-sectional imaging and 3D printing among groups of students and found those using the new tools demonstrated better knowledge outcomes.

"Cross-sectional imaging and 3D printing offer valuable tools for enhancing the teaching of spinal anatomy in undergraduate medical education," wrote first author Dr. Antonio Jesús Láinez Ramos-Bossini and colleagues. Current spatial understanding among students of many anatomical structures is based on conventional anatomical illustrations. This approach is hampered by intrinsic limitations of two-dimensional representations, however, and this may translate into problems in recognizing anatomy in the clinical setting, according to the authors.

Conversely, cross-sectional imaging and 3D printing

represent state-of-the-art approaches to improve anatomy teaching compared with traditional learning, but their use in medical schools remains limited, they added.

Thus, the group explored implementing these tools and aimed to determine whether they could be used to improve undergraduate medical education.

The researchers selected 40 undergraduate students in the same basic anatomy course and divided them into two groups. Twenty students were exposed to standard learning, cross-sectional imaging, and 3D-printed models during the academic year to learn basic concepts, and 20 students only received the standard university training. The study was conducted during the university's second semester between February and July 2022.

The control group received a total of 10 hours of conventional theory regarding the normal and pathological spine, and 10 hours of practice with traditional 2D illustrations and ideal anatomical models of the spine, in alignment with the standard university curriculum.

The intervention group was exposed to an identical 10-hour conventional theory program, yet further engaged in a 10-hour practice regimen using interactive 3D models, cross-sectional imaging examinations (CT and MRI), and 3D printed models.

After the learning period, both groups took a 20-question multiple-choice test on spinal anatomy and spinal conditions with four possible answers and only one correct answer.

According to the findings, students exposed to cross-sectional imaging and 3D printing demonstrated better knowledge outcomes compared to the control group. In general, the experimental group showed a higher frequency of correct answers than the control group (79.8% vs. 55.3%).

However, the rate of students who passed the test did not significantly differ between both, the group added. Ultimately, the results are in agreement with those found in previous studies, although the corpus of evidence in this area is still limited, the researchers wrote. Nonetheless, both anatomists and clinicians agree that accurate knowledge of anatomy and variations is vital to ensure safe and efficient clinical practice, they added.

"Radiologists are well positioned to lead the integration of these technologies, and further research should explore their potential in teaching anatomy across different anatomical regions," the group concluded.

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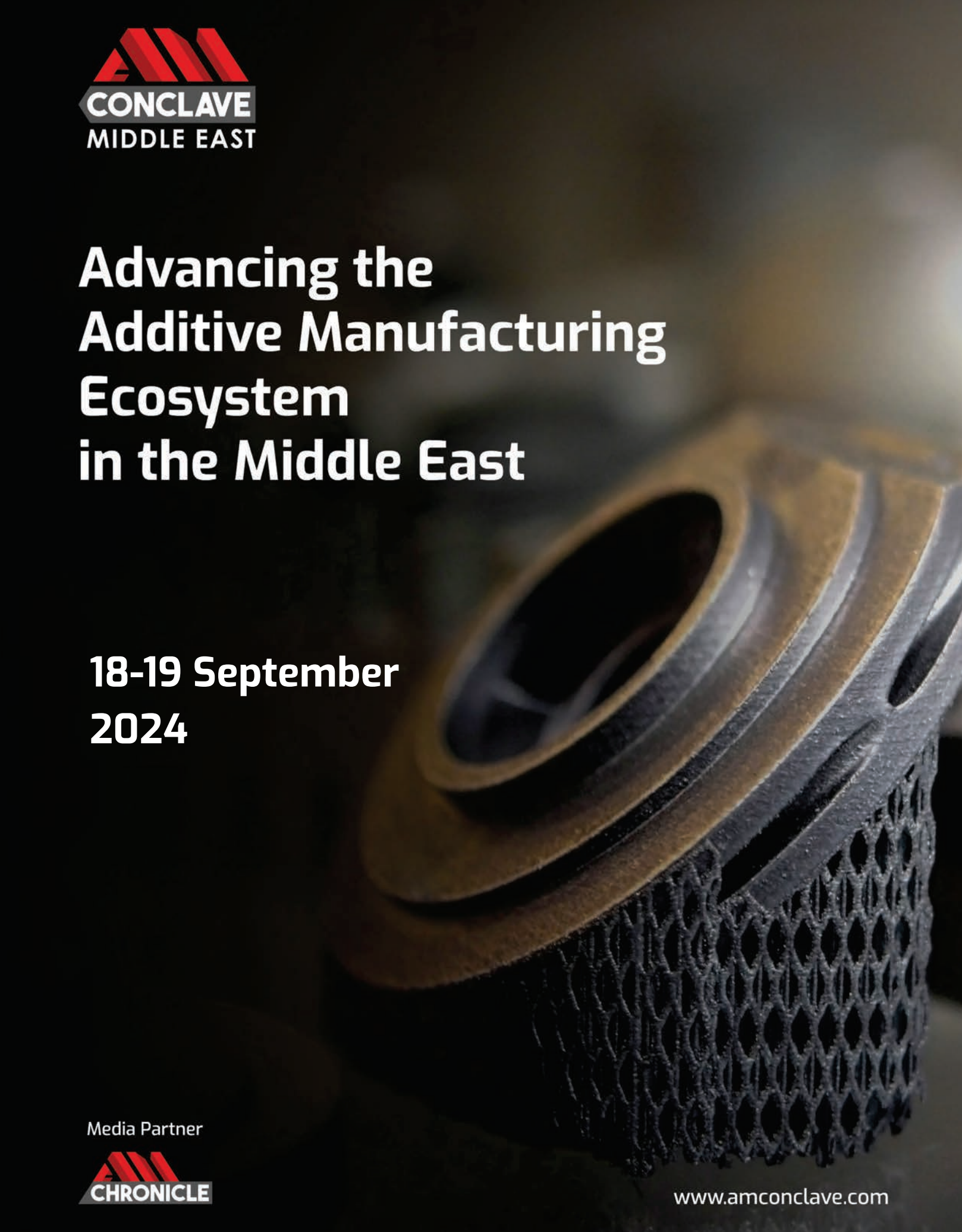

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