Desktop Metal

CASE STUDY

Ultra Safe Nuclear

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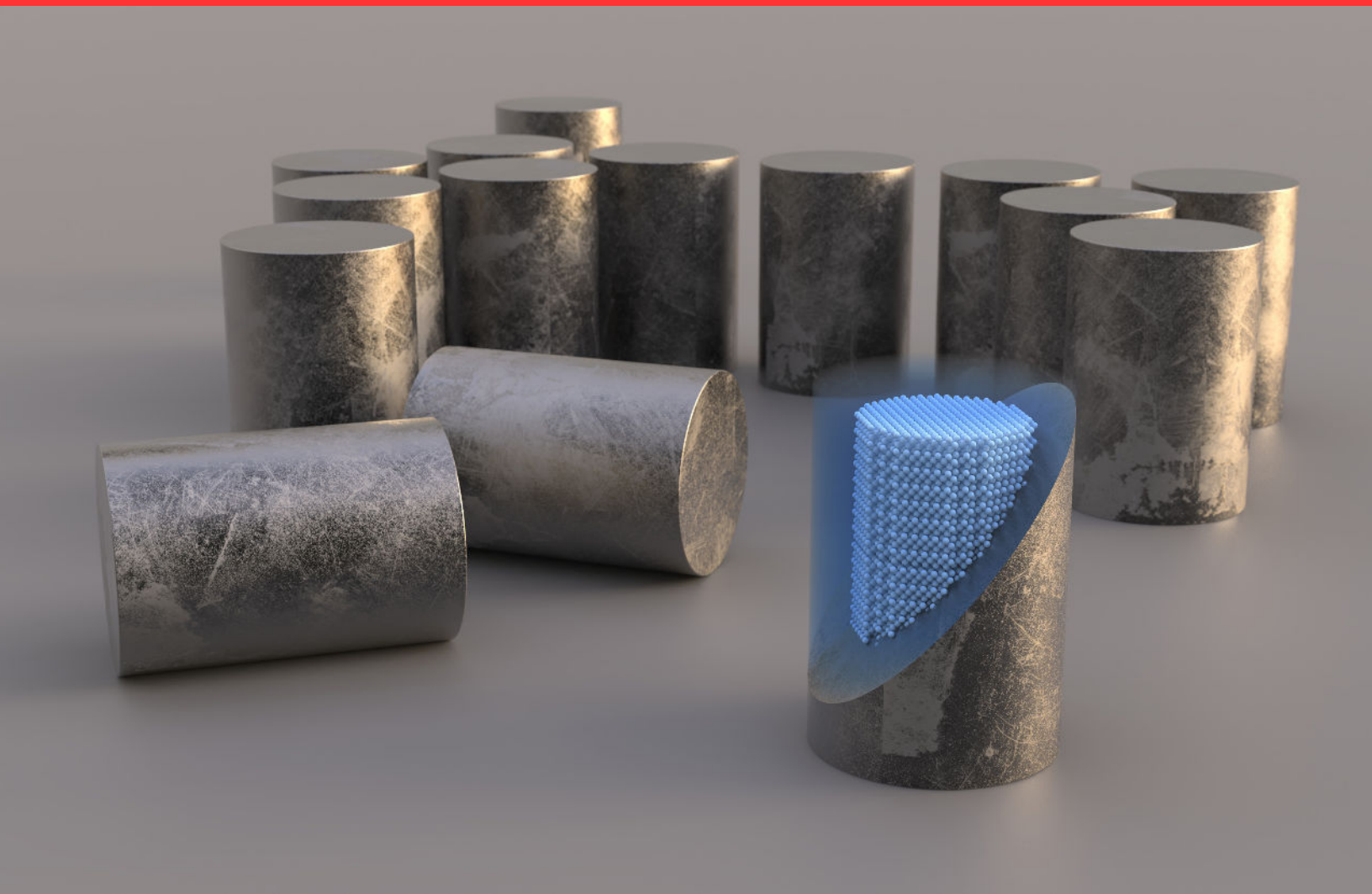
Binder jet 3D printing a new nuclear future with silicon carbide



ULTRA SAFE NUCLEAR

Customer
Ultra Safe Nuclear Corporation

Location
Seattle, Washington

Industry
Energy

Application
Nuclear Micro Modular Reactors

Machines
InventX, X25Pro, X160Pro

Material
Silicon Carbide

Website
www.usnc.com

Introduction

Ultra Safe Nuclear Corporation (USNC), a wholly U.S.-controlled corporation headquartered in Seattle, is a global leader in the deployment of micro reactors, and a strong vertical integrator of nuclear power technologies. The company is committed to bringing safe, commercially competitive, clean and reliable nuclear energy to power markets throughout the world. USNC is demonstrating MMR Energy Systems at the Canadian Nuclear Laboratories in partnership with Ontario Power Generation and at the University of Illinois, and has started new projects to further deploy its technology in the United States, Canada, and Europe. The company adheres to strict inherent and intrinsic safety principles through technological innovation in fuels, materials, and design. USNC is Reliable Energy. Anywhere.

Creating next-generation nuclear to power the future

More than a dozen countries around the world are now collaborating in a global race toward Generation IV – next-generation concepts in nuclear energy seen as vital to supplying carbon-free energy to a world with ever-increasing demands for electricity.

While renewable sources such as solar and wind continue to grow, a conventional wisdom has taken root in energy circles that nuclear stands alone as a reliable baseload energy source, one that is to operate continuously to meet the minimum level of power demand 24/7 without negative environmental consequences.

In this environment, Seattle-based Ultra Safe Nuclear Corporation (USNC) is blazing the way for a group of innovative companies working to bring advanced nuclear concepts to market, and where new methods of

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Dr. Kurt A. Terran, Executive Vice President, USNC's Core Division, works with advanced techniques like binder jet 3D printing to manufacture innovative nuclear reactor components

manufacturing, such as 3D printing, are often necessary to deliver all-new designs that deliver optimal performance in unique materials.

Internationally recognized nuclear fuel expert Dr. Kurt A. Terrani, the former National Technical Director at Oak Ridge National Laboratory (ORNL), joined the team at Ultra Safe Nuclear (USNC) in February 2020 to advance the company's mission of producing safe, controlled, and reliable nuclear energy on demand, anywhere in the world. He said small and advanced reactors, which run on different fuels and coolants while operating in different ways than the gargantuan nuclear facilities of the past, will deliver a paradigm shift in nuclear energy, one that the world especially needs now.

"Ultra Safe Nuclear is on the bleeding edge of nuclear fuel and reactor design, pioneering new advances in safety and performance," he added. "Powering up a new generation of micro reactors represents a watershed moment in zero-carbon energy production in the U.S. and worldwide."

Born out of crisis: USNC and manufacturing innovation

USNC's journey started in 2011, the same year an earthquake hit Japan. The Fukushima Daiichi nuclear power facility shut down operations as designed. Fifty minutes after the quake, however, the facility was hit with a tsunami, flooding and destroying all but one of the power generators used to keep cooling water circulating, leading to a meltdown and the subsequent explosion of three reactors.

The tragic accident also hit the nuclear industry at an already-tough time. The high cost of traditional reactors, in addition to other high-profile accidents such as Chernobyl, had already been slowing their development and escalating their decommissioning in many countries. At the same time, many governments were beginning to come to the incongruent conclusion that nuclear is actually one of the most reliable, portable, and green baseload energy sources.

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The United States, EU, Canada, Japan and many other states and countries now view nuclear power, which generates no CO2, as vital as world electricity consumption continues to escalate.

Leading nuclear experts, such as Terrani, had known for some time there was a better way to execute safe nuclear energy. The technologies used in facilities such as Three Mile Island and Fukushima dated back to the 1950s and 1960s, when advanced and safe materials and their methods of manufacture weren't available.

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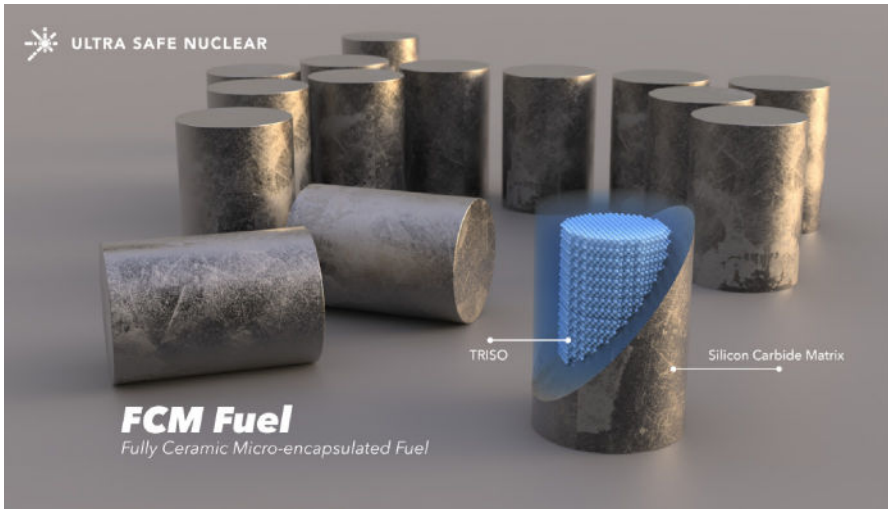
USNC's innovative Fully Ceramic Micro-encapsulated (FCM) Fuel is made possible by binder jetting silicon carbide matrix designs to keep radioactive material safely enclosed and contained at all times.



While calls to phase-out nuclear power were growing louder, the founders of Ultra Safe Nuclear knew that walking away completely would pose dire consequences in the fight against climate change and the resilience of global electricity systems.

Instead, they chose to focus on Generation IV Nuclear Energy and a technology that would allow them to control nuclear fission and prevent accidents altogether.

Innovative approach requires innovative manufacturing

The key to their approach is Fully Ceramic Micro-encapsulated (FCM) fuel, the manufacturing of which is enabled by Desktop Metal innovative binder jet 3D printers and their ability to 3D print silicon carbide heat-resistant ceramic particles in unique geometries that can safely surround a standard type of nuclear fuel particle known for its safety.

Today, USNC is using the novel approach to fuel its extremely reliable and safe micro modular reactor (MMR™) energy systems. Application of Desktop Metal binder jet 3D printers facilitates a key step in manufacturing of USNC's fuel, which is vital to executing the organization's underlying innovation.

Their approach is gaining momentum, with testing of USNC's FCM fuel underway by the Nuclear Research & Consultancy Group in the Netherlands (NRG Petten). Separately, USNC, through its joint venture Global First Power

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About Modular Reactors

- Small Modular Reactors (SMRs) are defined as producing up to 300 megawatts (MW) of power, while Very Small Modular Reactors (vSMRs) or microreactors produce up to 20 MWs of power per module
- A single MW powers about 800 average U.S. homes for a year
- Microreactors are highly transportable and will likely power future bases on the Moon and Mars, as well as orbiting space stations

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USNC's micro modular reactor (MMR) units can be linked as needed and harmonize with renewables to help meet 100% of demand around the clock to provide power to remote locations. "Complex systems like modular reactors for on-demand power, together with renewables, brings about a reliable and highly cost-effective power source," Terrani said.

is also working to deploy its first-of-a-kind MMR at Chalk River Laboratories, a site owned by Atomic Energy of Canada Limited and managed by Canadian Nuclear Laboratories. Currently, an effort is underway seeking a License to Prepare Site from the Canadian Nuclear Safety Commission (CSNC).

"Small modular reactors represent one of the most exciting areas of new nuclear innovation in Ontario and are a potential game-changer for the energy industry," said Todd Smith, Minister of Energy. Small reactors "with their versatility and ability to generate clean, low-cost energy, could provide the perfect solution for unique energy challenges, such as powering remote communities and mines that currently rely on expensive diesel power."

Shifting the nuclear paradigm

To deliver its innovation, USNC focused on combining a highly advanced and safe reactor system design with a highly advanced and safe fuel system. This combined approach, leveraging breakthroughs such as advanced manufacturing, yielded approaches that could take a six-decade-old technology and transform it to deliver a safer, more efficient reactor in the 21st century.

"When you do that, through exploiting fundamental laws of nature, we've created a design for a passively safe reactor, so you don't need a concrete dome, exclusion zone, or big water reservoir because it's inherently safe," Terrani said, explaining the idea behind USNC's approach. We're leveraging a high-temperature resistant fuel with multiple inherent barriers to radiation release at the center of our reactor system. That is the essence of the Ultra Safe Nuclear approach."

Capitalizing on a technology dating back to the 1960s, Ultra Safe Nuclear produces smaller-scale coated fuel particles, or micro encapsulated spheres, known in the industry as TRISO, a tristructural isotropic particle fuel seeing a resurgence in the race to deliver Generation IV nuclear reactors.

"That's quite a mature technology shown to provide extreme resistance to radionuclide release under a whole host of conditions," Terrani said. Traditionally, these fuel microspheres would be put into a soft graphitic matrix. However, these were not structurally strong and served as a poor barrier to radionuclide release.

USNC's answer was to replace this graphitic matrix with a refractory ceramic: silicon carbide (SiC). SiC is a technical ceramic material with extreme environmental stability that is often used in aerospace, armor, plasma shield, and high-temperature applications. The conditions within a nuclear reactor are some of the harshest in all of industry, yet SiC doesn't shrink or excessively swell like the traditional graphitic matrix and has a very high resistance to oxidation and corrosion, offering unique stability under all the demanding conditions of the nuclear reactor core.

The problem with SiC, however, is that it's an incredibly cumbersome material to manufacture or form into complex parts. For decades, despite

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the industry's desire to work with silicon carbide, there was no viable or affordable manufacturing process to transform highly pure, crystalline, nuclear-grade SiC into the shapes and forms needed for nuclear applications. Not until 3D printers began processing the material, anyway.

Desktop Metal binder jet 3D printing enables innovation

Highly similar to paper printing, binder jet 3D printing is widely regarded as the fastest method of 3D printing for high-volume output. The technology inkjets a binder into a bed of powder particles such as metal, sand, or ceramic to create a solid part, one thin layer at a time. Importantly for 3D printing SiC, the whole process is carried out at low temperatures.

"There was a whole host of additive manufacturing methods out there, but a large portion of those rely on a high-temperature process during deposition," Terrani explained. "With metals they're melting the particles to connect them together, but you can't do that with the high melting point of silicon carbide. Binder jet technology is unique because it really relies on the physical characteristics of the powder, and it's essentially highly agnostic to the chemical and phase structure of the material. So, we can select highly pure, highly crystalline carbide feedstock powder, nuclear grade powder, and then form these really complex geometries, and that just wasn't previously possible."

Binder jet 3D printing directly from digital design files without the need for tooling allows the USNC team to iterate their designs quickly and create unique shapes not otherwise manufacturable.

The 3D printed SiC fuel forms may have complex geometries that act as shells for the nuclear fuel particles. Silicon carbide will often be infiltrated with silicon or other matrices for densification; however, this is not an option in a nuclear environment. "Radiation will affect one material one way and another differently, so material uniformity and homogeneity is key," Terrani said.

> **"Binder jet really shines. It is a low-cost and high-yield process** for us as a part of our complex serial manufacturing"
>
> Dr. Kurt A. Terrani, Executive Vice President, USNC's Core Division

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By marrying binder jetting with chemical vapor infiltration to fill the porous SiC structure with more high-purity crystalline silicon carbide, USNC is able to realize highly complex, near-net shapes without the need to sinter the SiC material, apply any pressure, or introduce secondary phases.

3D printing ready for prime time

The team at USNC already had many decades of experience processing ceramics, which gave them a unique perspective in doing a full lifecycle analysis of their production, including costs, schedule, and yields. “Binder jet really shines. It is a low-cost and high-yield process for us as a part of our complex serial manufacturing,” Terrani said of Desktop Metal’s SiC printing.

Compared to the traditional way of processing technical ceramics, including mixers to create slurries, injection molders, and furnaces, Terrani said binder jet 3D printing is simple and elegant. Most importantly to his team, he said, it’s also a “cost-effective and reliable process.”

Beyond production efficiencies, USNC’s 21st century manufacturing strategy with binder jet 3D printing allows USNC to optimize the performance of their reactors by tapping the design freedom that comes with 3D printing. Previously the team was limited to one design, mass produced from hard tooling. Because this tooling was expensive and hard to change with long lead times, designers made a single design as generic yet efficient as possible.

3D printing technical ceramics

Binder jetting specialty materials on the Desktop Metal X-Series was developed with scalability in mind to drive innovative applications from R&D and prototyping to serial production with repeatable performance across a range of machines. USNC develops applications on an InnoventX before scaling them for production on the X25Pro and X160Pro. Features of the X-Series machines like top-of-the-line piezo printheads and Triple ACT powder compaction deliver industry-leading density in a variety of materials, including hard to process powders like silicon carbide and other technical ceramics.

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X160Pro binder jet system ramps up applications developed on the innoventX or X25Pro to mass-production volumes

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"With binder jetting we have the design freedom to have unique parts – we don't need to make the same thing," Terrani said. This design freedom allows shapes, wall thicknesses, and cooling channels to be tailored to each USNC reactor for operational efficiency and optimal safety.

> **"Binder jetting allows us to create a new paradigm of safe, reliable, carbon-free nuclear energy** for use by industry and remote communities"
>
> Dr. Kurt A. Terrani, Executive Vice President, USNC's Core Division

Beyond performance, the ability to create unique designs en masse with 3D printing allows USNC to add an additional layer of quality assurance to its mission of safe, responsible nuclear energy. "We print an ID on these parts, so from the moment of birth we track the reactors' manufacturing DNA throughout production, operational lifetime, and upon their discharge," Terrani said. "Binder jetting allows us to create a new paradigm of safe, reliable, carbon-free nuclear energy for use by industry and remote communities."

Desktop Metal

About Desktop Metal Inc.

Desktop Metal, Inc. is accelerating the transformation of manufacturing with end-to-end metal 3D printing solutions. Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost, and quality to make metal 3D printing an essential tool for engineers and manufacturers around the world. In 2017, the company was selected as one of the world's 30 most promising Technology Pioneers by the World Economic Forum, and was recently named to MIT Technology Review's list of 50 Smartest Companies. For more information, visit www.desktopmetal.com.

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CASE STUDY

TECNALIA
Research & Innovation

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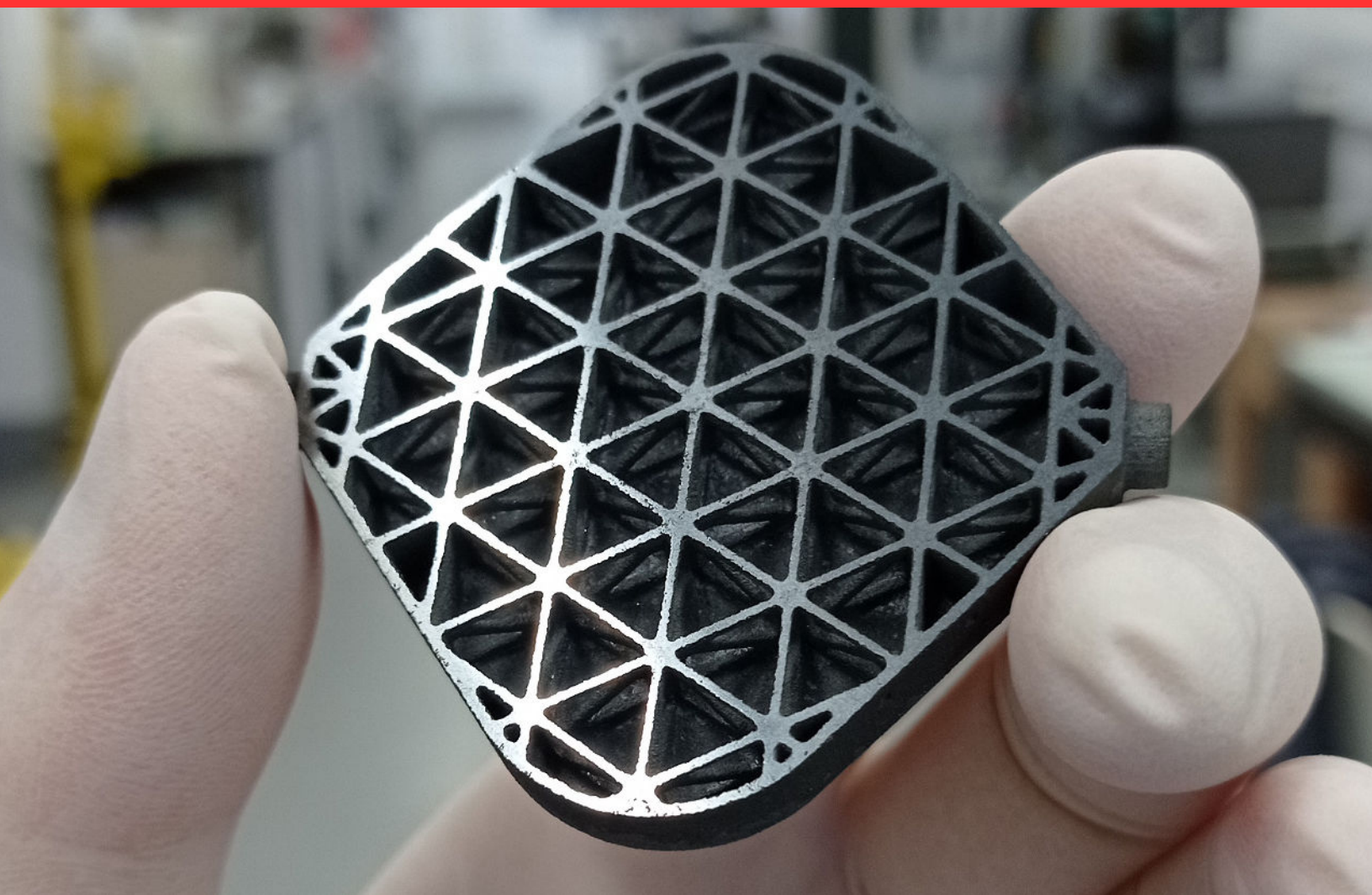
Sending optimized silicon carbide into space with binder jetting



MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Aeroespacial

Customer
TECNALIA Research & Innovation

Location
San Sebastián, Spain

Industry
Space

Application
Satellite optical mirror

Machines
InventX®

Material
Silicon Carbide

Website
www.tecnalia.com

About TECNALIA

TECNALIA Research & Innovation is a private, independent, non-profit applied Research Centre of international excellence. Legally a Foundation, TECNALIA is the leading private and independent research and technology organization in Spain and one of the largest in Europe, employing over 1,400 people, including 248 PhDs, with income of near €110 Million in 2019.

The team at TECNALIA focuses on one goal: to transform technological research into prosperity, meaning wealth to improve people's quality of life by generating business opportunities for industry. TECNALIA is committed to generate major impacts in economic terms, by means of innovation and technological development, addressed by 6 business divisions, covering economic sectors of Energy, Industry, Transportation, Construction, Health and ICT. TECNALIA has been granted over 396 patents and promoted more than 30 spin-off companies. Learn more at www.tecnalia.com

About SENER

SENER Aeroespacial has been a leading supplier of high-performance aerospace systems for Space, Defence and Science for more than 50 years, with high added value technological developments. In Space, it supplies electromechanical components and systems, navigation systems (GNC/AOCS), communications, astronomy and optics systems for Space, and it is currently participating in the main programs of ESA and NASA (including Euclid, Meteosat Third Generation, Solar Orbiter, JUICE, Proba-3, Hubble, Galileo, Rosetta, Gaia, Herschel and Planck, IXV, BepiColombo and Mars 2020) and the European Southern Observatory. Learn more at www.aeroespacial.sener

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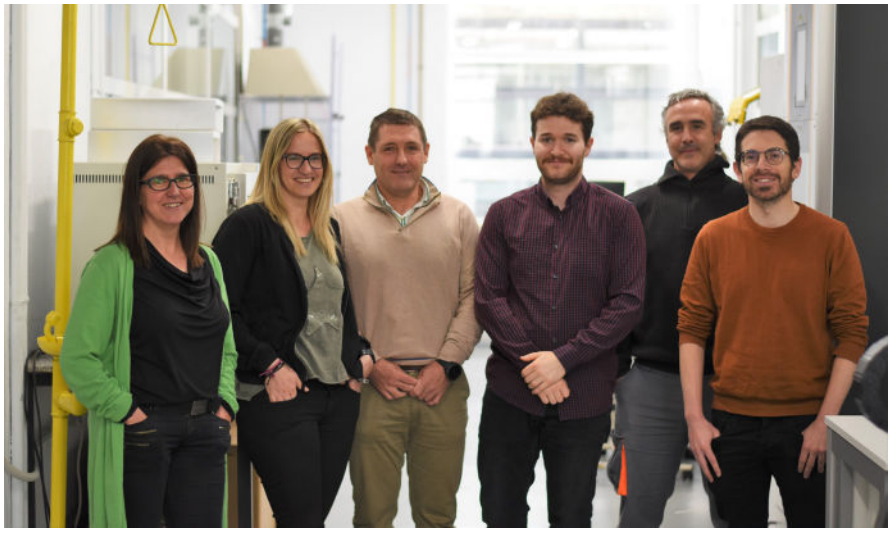
The TECNALIA team uses its material and manufacturing expertise to develop applications that transform knowledge into business opportunities for companies and GDP growth for society



Research paving the way for success in business, and in space

TECNALIA is a benchmark research and technological development center focused on transforming knowledge into business opportunities for companies and GDP growth for society. The Materials for Extreme Conditions research group belongs to the company's Industry and Mobility (I&M) division and focuses on the design, manufacturing, maintenance, and end of life of industrial products and services.

SENER Aeroespacial is a leading supplier of high-performance aerospace systems for space, defense, and science, adding value with technological developments for more than half a century. The company works with clients such as the European Space Agency (ESA) and carries out multidisciplinary projects in optomechanics, large mobile structures, and instrumentation and Infrastructure control.

TECNALIA and SENER Aeroespacial have worked on multiple collaborations in the space and aeronautic fields, and TECNALIA's Materials for Extreme Conditions research group serves the industry by helping companies find application success with disruptive binder jetting technology. With over 25 years of experience in developing the most advanced materials for the harshest conditions, the team helps improve competitiveness in a variety of strategic sectors. The knowledge and technological capabilities of the group cover all stages in powder metallurgy: from raw materials to the final component, complemented with design, characterization, and failure analysis capabilities.

Recognizing the importance of additive manufacturing (AM), the institute purchased its first binder jetting machine, a Desktop Metal InnoventX®, in 2017 to develop its expertise in sinter-based AM processes. Dr. Iñigo Agote, Project Manager and Group Leader at TECNALIA, explained the role his team plays in advancing the technology, saying "With our concentration of PhDs and materials knowledge we could be early adopters and implement the

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technology relatively easy. The companies we partner with, however, are still surveying the process and not sure where it fits, so we help fill that gap with our expertise to advance their applications."

The material flexibility of X-Series binder jetting technology allows TECNALIA to use its InventX system to process a range of powders that support various industries. For example, the team uses its expertise to optimize hard metal and tool steels that drive performance improvements in the cutting tool industry as well as processes technical ceramics like silicon carbide and alumina used in the most cutting-edge innovations in critical applications.

> "The binder jetting process allowed us to obtain parts close to the final component specifications for geometry and surface quality, and this **significantly reduced the cost associated with final operations"**
>
> **Dr. Iñigo Agote, Project Manager and Group Leader, TECNALIA**

A new way to process ceramics

The TECNALIA team has collective knowledge in materials for extreme temperature, wear, abrasion, and corrosive environments, making them the natural partner when SENER Aeroespacial and the European Space Agency (ESA) wanted to investigate a new manufacturing route for a satellite optical support. The harsh conditions of space travel require components with high dimensional stability, a coefficient of thermal expansion (CTE) compatible with their adjacent systems, and excellent surface quality and mechanical properties. Thus, ceramics are ideal for space applications because of their thermo-mechanical stability, high temperature performance, hardness, and light weight and TECNALIA brought the required material and process expertise to the table to apply to challenge.

"Space applications are always looking for weight reduction since this is directly linked to the final payload cost," said Agote, explaining how lightweighting is a systematic demand of aerospace companies today. Saving mass is one reason why the technical ceramic silicon carbide (SiC) is a highly sought-after material in this sector. It can be polished until its smooth with unique benefits of staying lightweight, strong, and with the thermal properties to adjust to temperature extremes seen in space.

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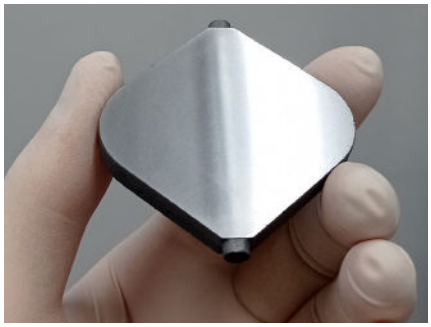

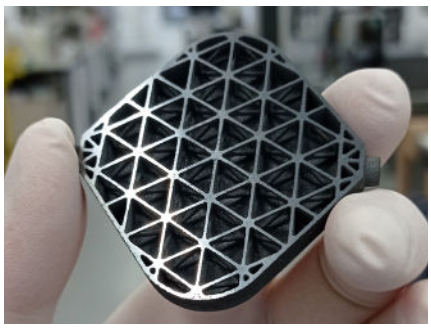

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The design optomized for additive manufacturing provided a 15% mass reduction while optomized production with binder jetting reduced final polishing time by 35%

However, fabricating SiC using traditional methods is both costly and difficult because of exactly these desirable high-performance properties. "The degree of shape complexity is limited when using more traditional production processes like cold forming and sintering," Agote said. "Parts require final machining if the geometry is complex and machining ceramics like SiC is a tough and expensive process."

Additive manufacturing was investigated to provide a near-net shape part to reduce the difficult and expensive machining and polishing post-processing steps. Binder jet 3D printing was identified as the only process able to create the unique SiC design with speed and precision, even among other additive technologies because the dark powder won't UV cure and the high melting point eliminates laser-based methods.

Still, even for binder jetting SiC poses challenges. As Agote explains, "It's a balance between powder flowability and sinterability. Very fine SiC powders, only a few microns, are excellent for sintering but tend to have poor flowability, easily compromising the quality of the powder bed." On the other hand, coarser powders flow better, yet can be detrimental in sintering to achieve the required part properties.

So, the TECNALIA team got to work identifying adequate SiC powders and defining the best processing steps. An exhaustive evaluation of the rheological properties of various grades of SiC began. Analyzing the Hausner ratios, cohesive index, among other tests, allowed them to better understand the flowability and cohesiveness of the powder to help identify the material for the optimum printing process that limits shrinkage during sintering. After the binder jetting process, the green parts were subjected to different Polymer Impregnation and Pyrolysis (PIP) cycles and final Capillary Liquid Silicon Infiltration (CLSI).

The flexibility of the InnoventX machine to customize parameter settings combined with the process and materials expertise of the TECNALIA team to tailor the properties for this application led to the breakthrough that delivered a final part with the required quality. The part could be printed in the InnoventX in 3 hours before PIP and infiltration with silicon for densification.

The near-net shape of the final Si-SiC component also provided a good surface quality that reduced the time required for final polishing by 35% compared to the traditional SiC component. The final part achieved the required CTE values, had isotropic properties, and were free of residual stresses.

"The binder jetting process allowed us to obtain parts close to the final component specifications for geometry and surface quality, and this significantly reduced the cost associated with final operations," Agote said. The new design also provided a 15% mass reduction. Binder jetting

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production provided improvements that positively impacted the final cost of the component while also optimizing the payload weight for space missions.

Ongoing material development for binder jetting

Supporting the ESA and companies such as SENER Aeroespacial aligned with the collaborate way TECNALIA uses their expertise. As members of EARTO and EUROTECH they play an important role in linking together European research centers. Through EU Framework Programmes they have participated in over 700 projects, coordinating nearly 150.

To date, TECNALIA has been granted nearly 400 patents and promoted more than 30 spin-off companies. The Materials for Extreme Conditions research group works with different sinter based additive manufacturing processes, such as binder jetting. The InnoventX system affords the team the flexibility to work with a range of materials, technical ceramics, and metals. “The team is eager to work with any powder they can get,” Agote says. While they continue developing Silicon Carbide, they also work with tungsten carbide cobalt and alumina, and are gearing up to tackle aluminum to continue bringing the most advanced innovations into space – and the mass market.

3D printing technical ceramics

Binder jetting specialty materials on the Desktop Metal X-Series was developed with scalability in mind to drive innovative applications from R&D and prototyping to serial production with repeatable performance across a range of machines. Applications can be developed on an InnoventX before scaling for production on the X25 Pro and X160 Pro. Features of the X-Series machines like top-of-the-line piezo printheads and Triple ACT powder compaction deliver industry-leading density in a variety of materials, including hard to process powders like silicon carbide and other technical ceramics.

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X160 Pro binder jet system ramps up applications developed on the innoventX or X25 Pro to mass-production volumes

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About Desktop Metal Inc.

Desktop Metal, Inc. is accelerating the transformation of manufacturing with end-to-end metal 3D printing solutions. Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost, and quality to make metal 3D printing an essential tool for engineers and manufacturers around the world. In 2017, the company was selected as one of the world's 30 most promising Technology Pioneers by the World Economic Forum, and was recently named to MIT Technology Review's list of 50 Smartest Companies. For more information, visit www.desktopmetal.com.

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CASE STUDY

Saint-Gobain Research North America

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Scaling 3D printing of technical ceramics with binder jetting

Customer
Saint-Gobain Research North America

Location
Northborough, MA

Application
Material research and commercial application development across a variety of industrial sectors

Machines
InventX, X25 Pro

Material
High-performance technical ceramics including silicon carbide

Website
www.saint-gobain.com

About Saint-Gobain

Saint-Gobain designs, manufactures, and distributes materials and solutions for the construction, mobility, healthcare and other industrial application markets. Developed through a continuous innovation process, they can be found everywhere in our living places and daily life, providing wellbeing, performance, and safety, while addressing the challenges of sustainable construction, resource efficiency and the fight against climate change.

This strategy of responsible growth is guided by the Saint-Gobain purpose, “MAKING THE WORLD A BETTER HOME”, which responds to the shared ambition of all the women and men in the Group to act every day to make the world a more beautiful and sustainable place to live in.

Developing new capabilities for ceramic binder jetting

Saint-Gobain is a global leader in innovative ceramics. The company designs, manufactures, and distributes a variety of technical materials using advanced manufacturing to develop innovative solutions in a variety of sectors. Its ceramics businesses have an unmatched range of ceramic processing technologies to solve customer challenges, including binder jet 3D printing. With two different ExOne machines, Saint-Gobain Research North America is forging the path to industrial adoption of more efficient, more sustainable designs through ceramic materials research and application development.

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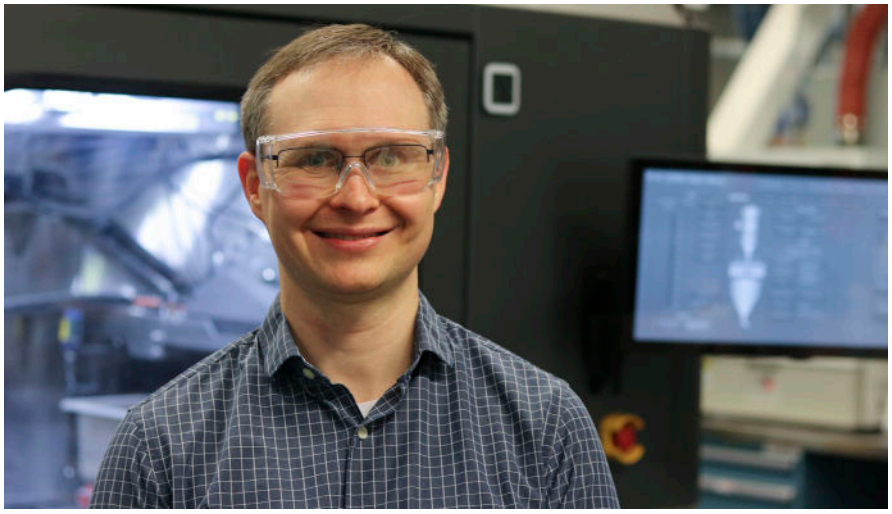
Nicholas Orf, Principal Scientist and Additive Manufacturing Group Leader at Saint-Gobain Research North America with the X25 Pro



The R&D organization at Saint-Gobain comprises local teams dedicated to specific businesses, as well as a network of eight Transversal R&D centers that serve all the businesses of Saint-Gobain worldwide. These Transversal centers are knowledge hubs to develop new capabilities for the company to utilize in the future. Saint-Gobain Research North America, located in Northborough, Massachusetts, is one such Transversal R&D center and home to a 3D printing team dedicated to improving the production or performance of Saint-Gobain products via additive manufacturing, as well as advancing the use of 3D printing for ceramics within the Saint-Gobain portfolio.

"The team is a centralized service for all Saint-Gobain business," said Nick Orf, Additive Manufacturing Group Leader. "We work closely with our business unit colleagues to identify where Saint-Gobain materials can be used in the 3D printing industry, where can we use the technology to develop new products internally, and where we can connect our business with startups and manufacturers in the AM space."

> **"Being able to demonstrate scalability is important."**
>
> **Nicholas Orf, Principal Scientist and Additive Manufacturing Group Leader**
> **Saint-Gobain Research North America**

Using Desktop Metal binder jet 3D printing, Saint-Gobain works to develop innovative new products and create a more efficient manufacturing processes. "We see binder jetting as a highly scalable technology, which is obviously very important if the process is to be used for commercial production," Orf said.

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Saint-Gobain invested in its first Desktop Metal binder jetting machine, an InnoventX, in 2018. The flexibility of the machine allowed the team to perform research on a variety of their ceramic materials. To further advance the initial materials research into production-ready applications, the company added an X25 Pro in 2020.

"We chose these machines because of the ability to develop applications for a variety of materials and then scale it within the machine family," Orf said of the Innovent entry-level machine and the X25 Pro production system. "Being able to demonstrate scalability is important. We've used the Innovent for years for prototyping concepts for several of our businesses. More recently, we've been seriously focusing on scaling a few of the most promising product designs and think we will be able to handle the yearly part production on the X25 Pro."

The two-machine setup at Saint-Gobain takes advantage of the versatility of the Innovent as a multi-purpose tool and the increased capacity of the X25 Pro for industrial adoption. "The X25 Pro build box fits our needs for making larger-size pieces or larger numbers of parts – both for customers and for the interest we've see internally from our businesses here," Orf said.

Density and porosity optimization are crucial to many of the team's programs. "We are so happy with the powder compaction capabilities from the Triple ACT technology on the X25 Pro that we're upgrading our InnoventX with the same capability so we have even better control of the microstructure of the parts we print," Orf said. Projects can then be reliably scaled up to the X25 Pro for

3D printing with scalability

Binder jetting specialty materials on the Desktop Metal X-Series was developed with scalability in mind to drive innovative applications from R&D and prototyping to serial production with repeatable performance across a range of machines. Applications can be developed on an InnoventX before scaling for production on the X25 Pro and X160 Pro. Features of the X-Series machines like top-of-the-line piezo printheads and Triple ACT powder compaction deliver industry-leading density in a variety of materials, including hard to process powders like silicon carbide and other technical ceramics.

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X160 Pro binder jet system ramps up applications developed on the innoventX or X25 Pro to mass-production volumes

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production. For future growth, the company could further scale applications into the X160 Pro.

Orf offers a positive outlook for the future of binder jet 3D printing at Saint-Gobain, noting the growing interest in the technology both within the company and across the entire manufacturing industry. The Saint-Gobain Research North America team is excited to explore new additive manufacturing applications utilizing the company's materials such as alumina, zirconia, and silicon carbide, among other high performance ceramic materials in the Saint-Gobain portfolio.

> "We are so happy with the powder compaction capabilities from the Triple ACT technology, . . . we have even **better control of the microstructure of the parts we print.**"
>
> Nicholas Orf, Principal Scientist and Additive Manufacturing Group Leader, Saint-Gobain Research North America

Desktop Metal

About Desktop Metal Inc.

Desktop Metal, Inc. is accelerating the transformation of manufacturing with end-to-end metal 3D printing solutions. Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost, and quality to make metal 3D printing an essential tool for engineers and manufacturers around the world. In 2017, the company was selected as one of the world's 30 most promising Technology Pioneers by the World Economic Forum, and was recently named to MIT Technology Review's list of 50 Smartest Companies. For more information, visit www.desktopmetal.com.

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