Desktop Metal

CASE STUDY

TECNALIA
Research & Innovation

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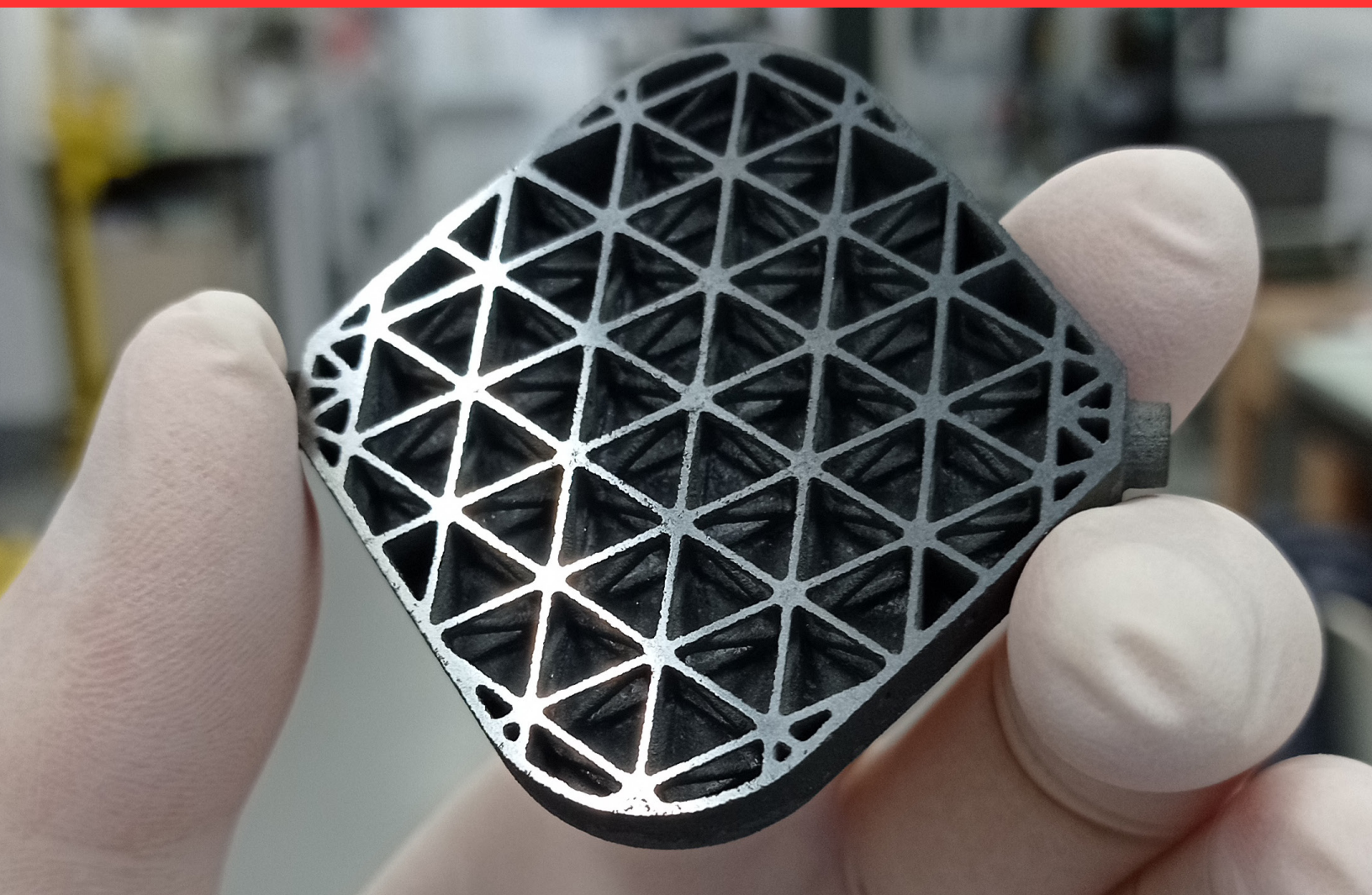
Sending optimized silicon carbide into space with binder jetting



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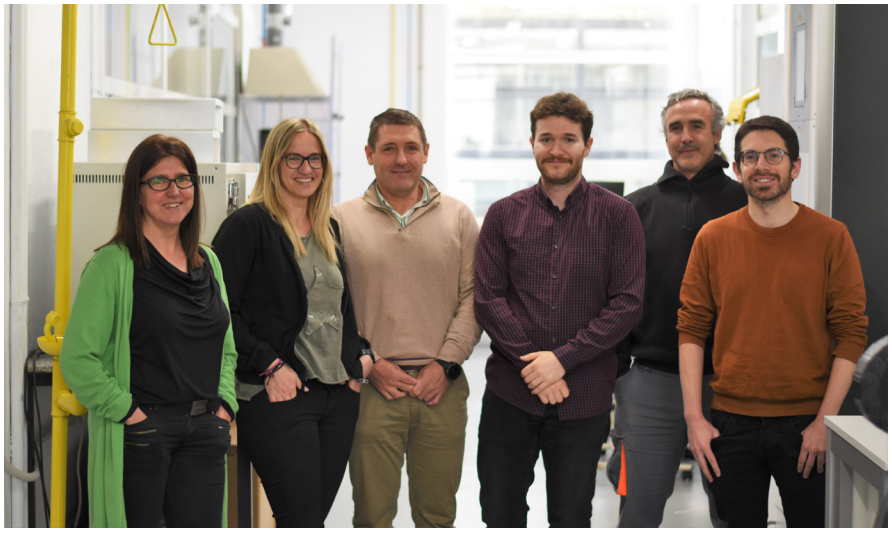
The TECNALIA team uses its material and manufacturing expertise to develop applications that transform knowledge into business opportunities for companies and GDP growth for society



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

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."

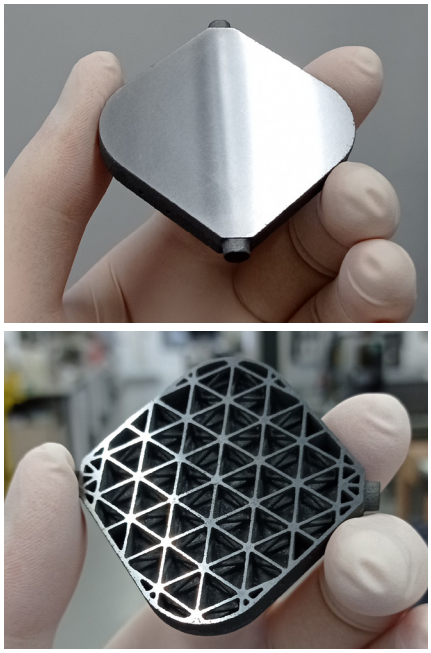
The material flexibility of X-Series binder jetting technology allows TECNALIA to use its InventX system to process a range of powders that support various industries. For example, the team uses its expertise to optimize hard metal and tool steels that drive performance improvements in the cutting tool 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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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

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

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.