



# Ultra-strong, heat-resistant components for demanding applications

**PEEK 3D printing at 3M BIC**

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3M BUCKLEY  
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CENTRE

## Introduction to PAEK, PEEK and PEK

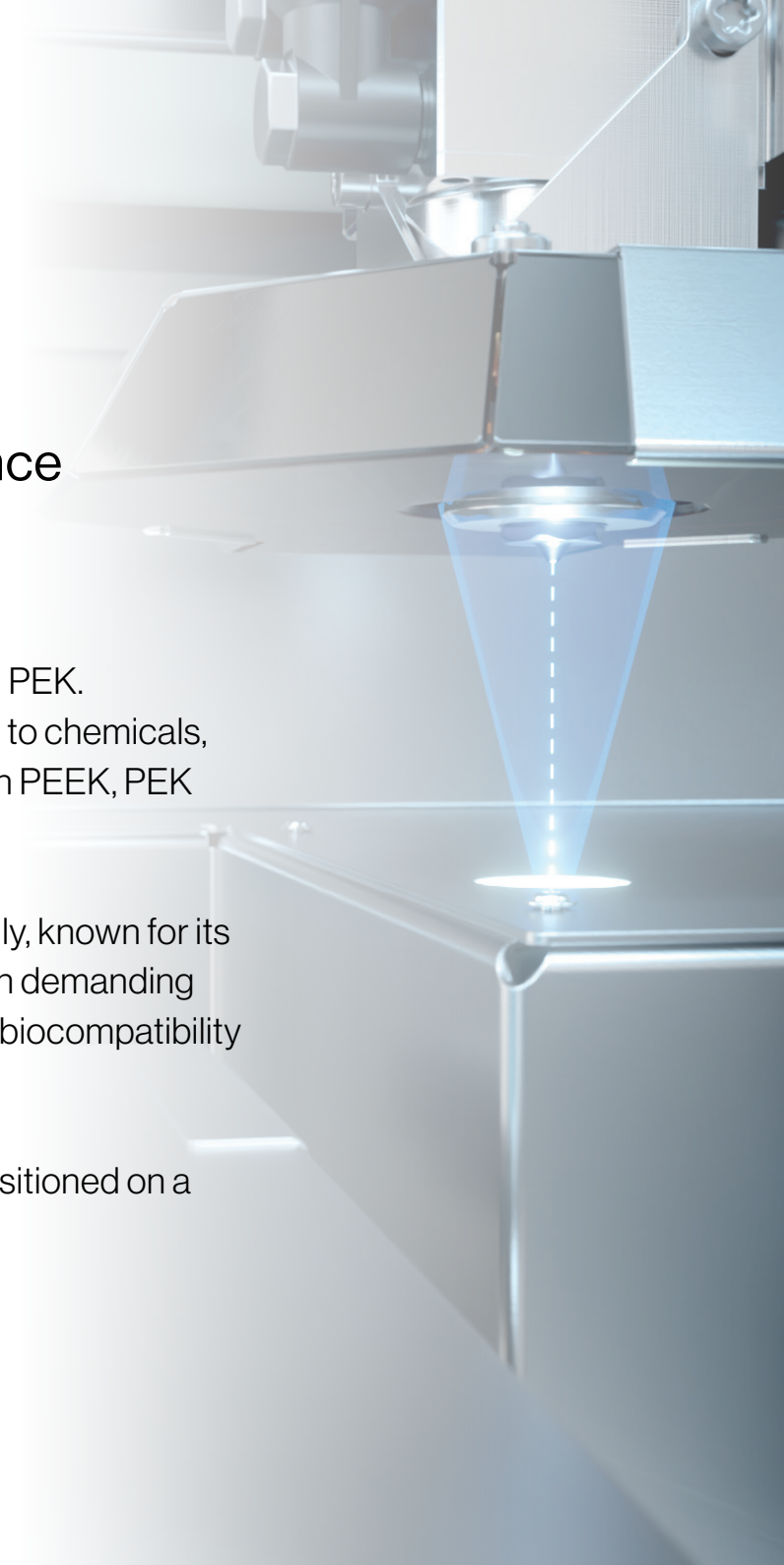
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PAEK (Polyaryletherketone), PEEK (Polyether Ether Ketone) and PEK (Polyether Ketone) are high-performance thermoplastics, each offering distinct properties.

PAEK refers to the entire family of polyaryletherketone polymers, including PEEK and PEK. PAEKs are valued for their toughness, high-temperature performance and resistance to chemicals, making them suitable for various high-performance applications. The choice between PEEK, PEK and other PAEKs depends on the specific application requirements.

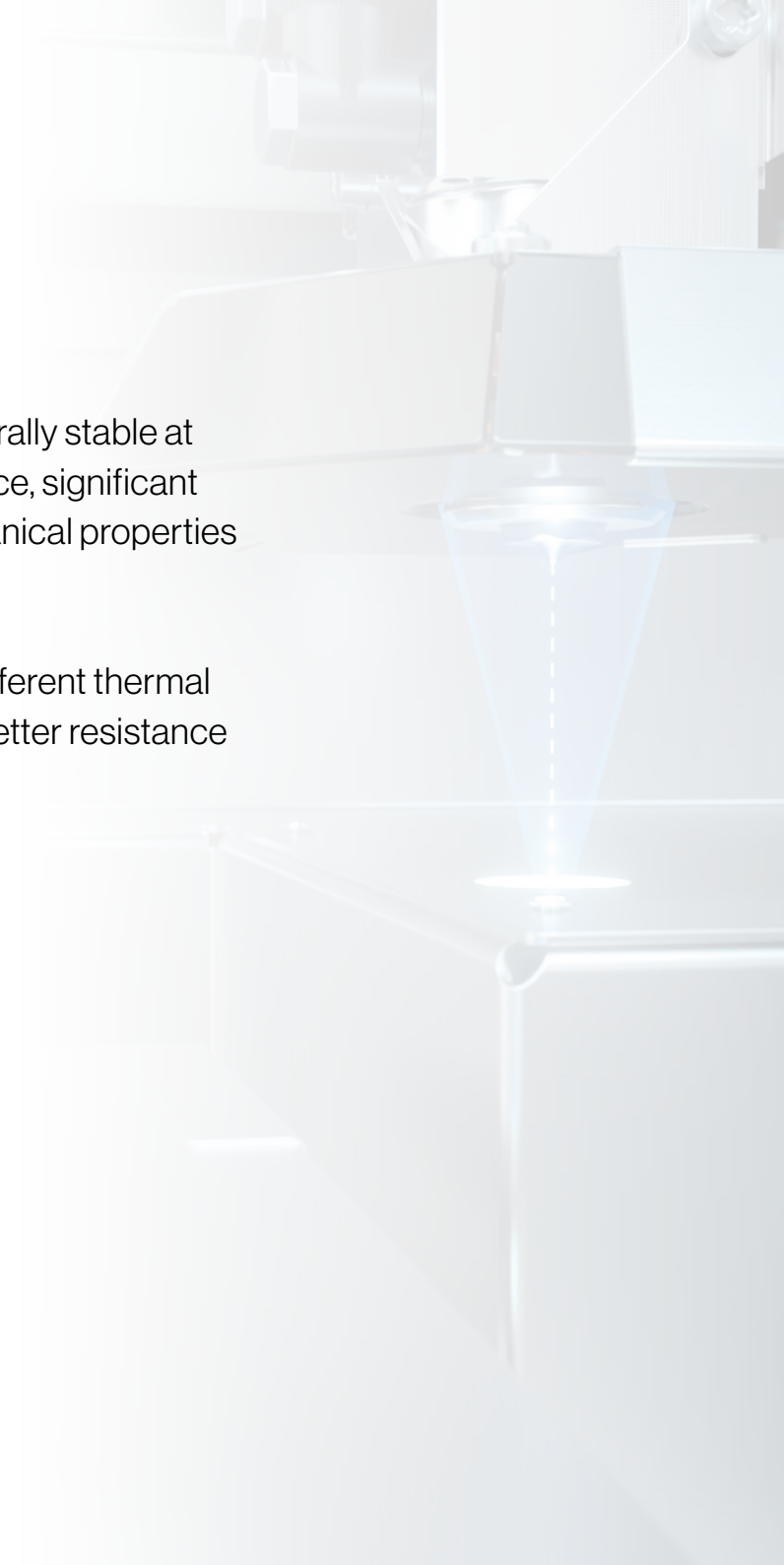
PEEK, a semi-crystalline thermoplastic polymer, is a subset of the broader PAEK family, known for its mechanical strength, chemical resistance and high thermal stability. It is widely used in demanding applications like medical implants, aerospace and automotive components due to its biocompatibility and ability to withstand harsh environments.

The chemical structure for PEEK is a sequence of ether (E) and ketone (K) linkage positioned on a backbone making this polymer unique.



PEEK is the most commercially used member of the PAEK family. Colourless, structurally stable at a wide temperature range (from  $-196\text{ }^{\circ}\text{C}$  to  $260\text{ }^{\circ}\text{C}$ ), it exhibits good chemical resistance, significant wear resistance and is biocompatible, plus under tensile loading conditions its mechanical properties are superior to that of most thermosets.

PEK, another member of the PAEK family, offers similar properties but with slightly different thermal and mechanical characteristics. PEK has a higher glass transition temperature and better resistance to chemicals and wear, making it suitable for even more extreme environments.



## Benefits of 3D printing in PEEK

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PEEK offers numerous advantages across various industries due to its exceptional properties and the efficiency of 3D printing technology:



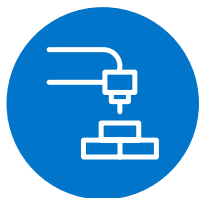
### **Rapid prototyping**

PEEK allows for quick, cost-effective production of functional prototypes, enabling extensive testing and validation before moving to low or mass production.



### **Design flexibility**

3D printing with PEEK supports complex geometries without added cost, fostering innovative designs unachievable with traditional manufacturing. This flexibility allows engineers to enhance system performance while reducing costs.



### **Low-volume custom manufacturing**

PEEK has the potential for creating custom medical implants and components in low volumes, eliminating the need for expensive moulds and tooling.





### **Customisation & cost-efficiency**

Despite higher initial costs, PEEK's durability and low maintenance lead to lower overall lifecycle costs. 3D printing with PEEK enables bespoke designs, meeting specific needs and creating tailored solutions efficiently. It also reduces material waste, making it ideal for low-volume part production.



### **Optimal performance**

PEEK improves performance by preventing corrosion, reducing friction and handling higher loads and speeds. Its extreme resistance to oil, gas, and chemicals, combined with a high HDT glass transition temperature (180°C), extends product lifespan, reducing costly replacements.



### **Weight savings**

PEEK's low specific weight (1.3 g/cm<sup>3</sup>) is a fraction of steel and aluminium, resulting in up to 80% weight reduction, which decreases maintenance, logistics, and installation costs.



### **Sustainable and scalable solutions**

3D printing with PEEK uses energy-efficient processes, minimising environmental impact. It is scalable for growing demands, particularly in the medical sector, ensuring consistent quality and performance.



## Attributes of PEEK materials in 3D printing

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PEEK in 3D printing has exceptional properties, including strength, thermal stability and biocompatibility, making it ideal for advanced applications across various industries.

### Ease of processing

The filaments are made from the grade of PEEK material which is especially suitable for extrusion purposes and has processing properties optimum for handling on our 3D printer.

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### Purity

The high purity filament is exceptionally of low outgassing.

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### High temperature performance

PEEK has a heat deflection temperature of 152 °C ensuring its structural stability at the operating temperatures of most conventional engineering applications. Its operating range lies from -196 °C to 260 °C.



### **Low smoke and toxic gas emission**

Under conditions of thermal combustion, pure PEEK is inherently flame resistant, demonstrating properties of a retardant whilst producing combustion gases of markedly low toxicity.

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### **Chemical resistance**

The 3D printed parts from our PEEK 450 filaments can withstand a wide range of organic solvents, hydrocarbons and acids.

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### **Mechanical strength**

Parts which are 3D printed from PEEK filaments can achieve high mechanical strength and stiffness.

### **PEEK material qualities:**

- High thermal resistance
- High chemical resistance
- High stress resistance
- Bio inert
- Low weight
- Post treatment possible



## Applications of PEEK

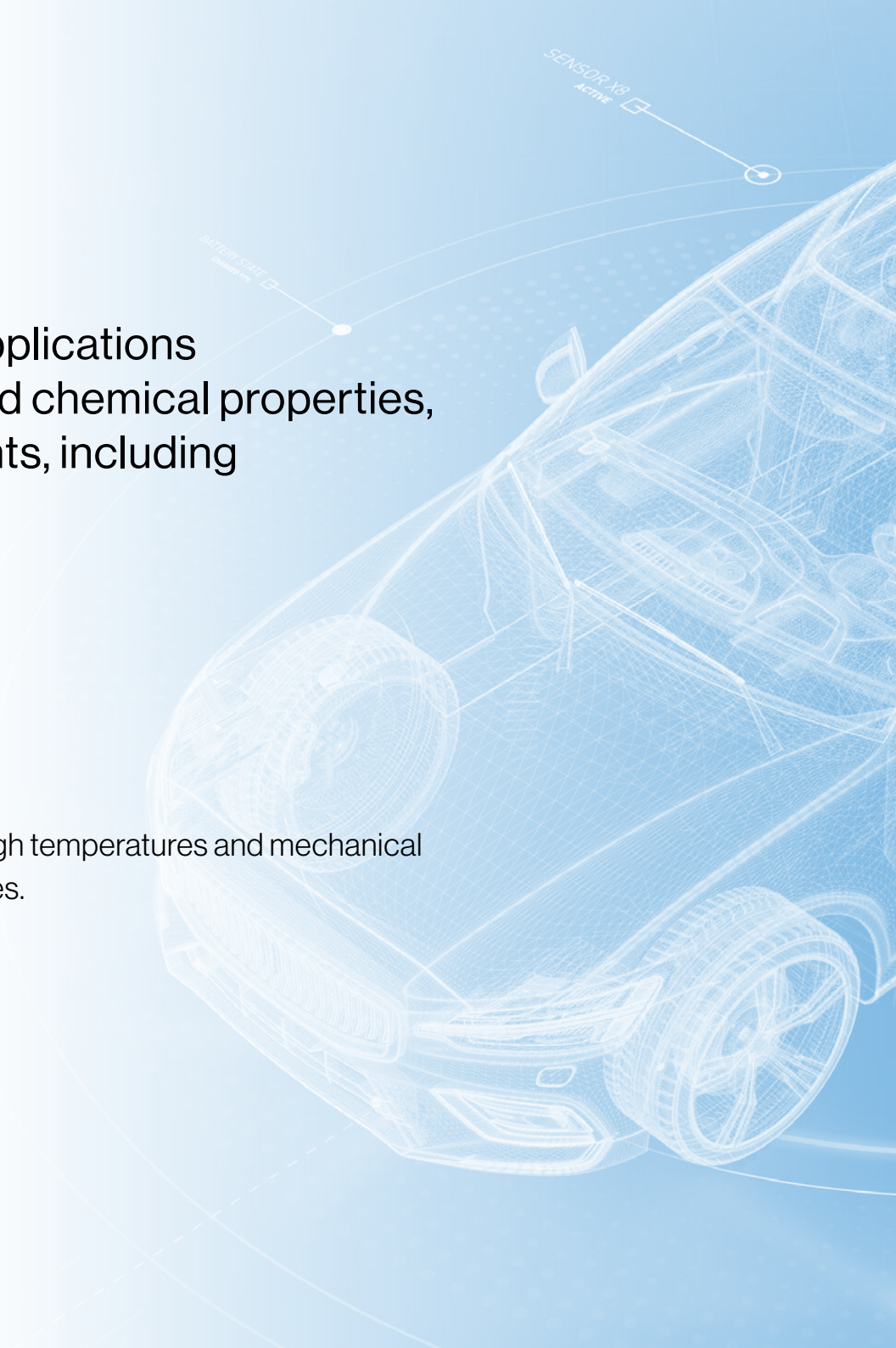
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PEEK is used in a wide array of demanding applications due to its exceptional mechanical, thermal and chemical properties, from food and drug to electrical components, including fixtures and chemical resistant parts.



### Automotive industry

In the automotive sector, PEEK is used for parts that must endure high temperatures and mechanical stress, such as in engine compartments and transmission assemblies.



## Applications of PEEK

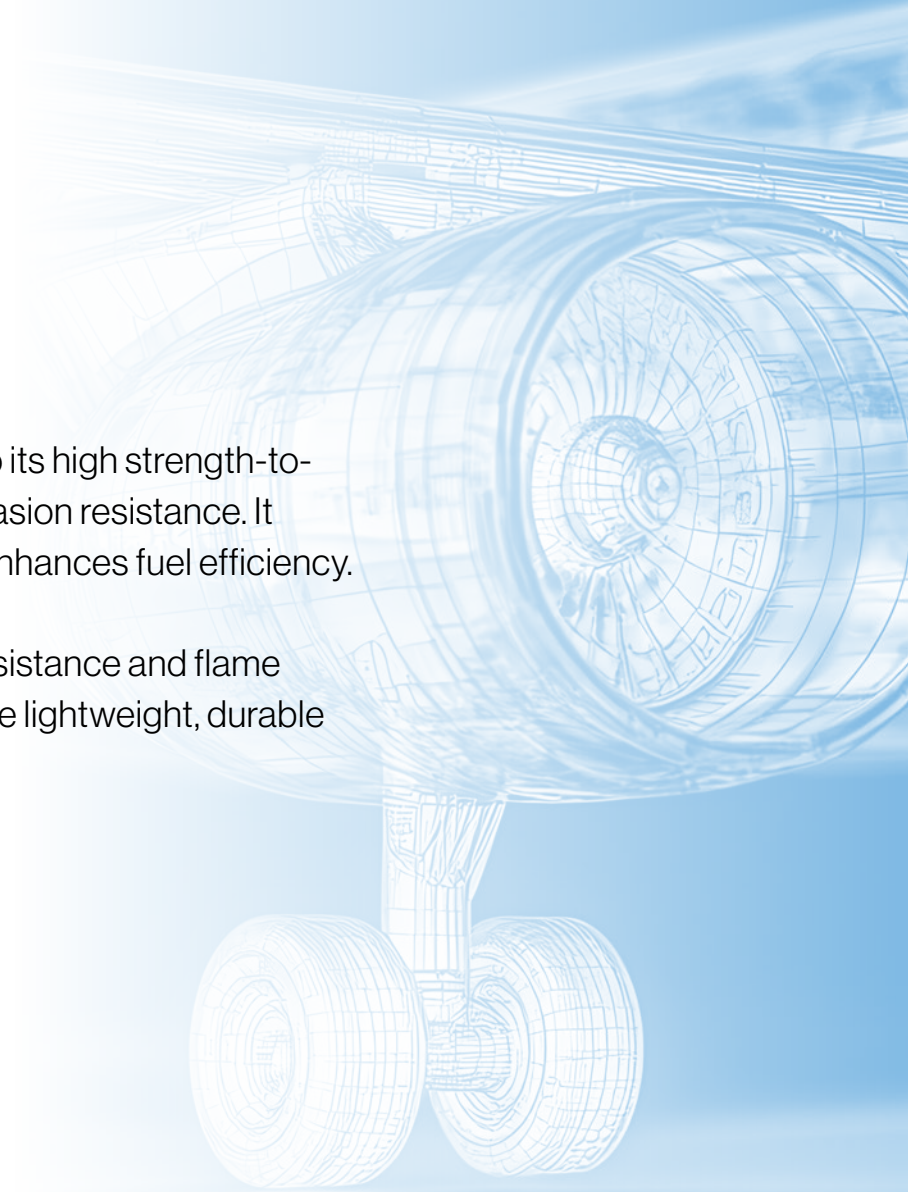
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### Aerospace industry

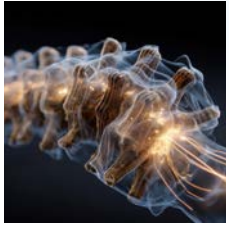
PEEK is ideal for aerospace components like seals, bearings and gears due to its high strength-to-weight ratio, extreme temperature resistance, and excellent chemical and abrasion resistance. It replaces metals like aluminium, reducing aircraft weight by up to 70%, which enhances fuel efficiency.

PEEK's unique properties, including high-temperature resistance, radiation resistance and flame retardancy, are ideal for the demanding conditions of the aviation sector, where lightweight, durable materials are essential.



## Applications of PEEK

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### Medical industry

PEEK is used in medical implants like spinal fusion cages, dental implants and potential joint replacements due to its biocompatibility, high strength and wear resistance. Its non-reactive nature and ability to withstand repeated sterilisation make it ideal for surgical instruments and devices.

As a high-performance polymer, PEEK is more flexible than metal and ceramic and this flexibility is an important property to have in an orthopaedic device. In fact, PEEK's flexibility is similar to that of cortical bone, so it moves, flexes and bears weight much like bone. As orthopaedic implants are designed to replace the motion and strength of bone, a bone-like modulus is highly valuable.

PEEK also allows clear imaging on X-rays, enhancing post-surgery monitoring.

## Applications of PEEK

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### Electrical & Electronic industry

PEEK is an excellent electrical insulator with outstanding thermal and chemical resistance, viable for use in high-temperature, high-pressure and high-humidity environments. It is widely used in computers, mobile phones, circuit boards and other electronic equipment. In semiconductor manufacturing, PEEK screws and fasteners are preferred for their chemical resistance, low outgassing and high purity, ensuring reliable performance in sensitive environments.

PEEK is also used for wire coatings, circuit board substrates and connectors, supporting the demands of the electronics industry.

## Applications of PEEK

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### Oil & Gas industry

PEEK components and fasteners are also widely used in the oil and gas industry. PEEK is resistant to chemicals and high temperatures, making it an ideal choice for downhole drilling applications. PEEK is used in various drilling components such as bearings and bushings, as well as electrical connectors, due to its high insulation properties.

PEEK is also ideal for seals, gaskets and back-up rings in oil and gas extraction plus processing equipment due to its ability to resist harsh chemicals and high-pressure conditions.

## Applications of PEEK

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### Food industry

PEEK meets quality, safety and regulatory compliance including most of the stringent food contact material requirements. This makes it an EFSA and FDA approved polymer. It can tolerate exposure to a multitude of chemicals, extreme temperature ranges and steam. Its application can be found in the food packaging manufacture process and oven parts.

In food processing, PEEK is used for components that require frequent cleaning and contact with harsh cleaning agents, as it does not degrade or contaminate the food products.

As technology advances, the applications of PEEK are likely to expand, further entrenching its role in modern manufacturing and engineering solutions.

## Medical PEEK v Industrial PEEK

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PEEK has a wide potential in the medical industry, particularly for implantable devices like spinal, dental and joint implants. Its popularity stems from its biocompatibility, meaning it does not trigger adverse reactions in the body. PEEK's resistance to wear, chemicals and radiation makes it ideal for medical devices subjected to constant stress and medical imaging equipment.

Medical PEEK, often manufactured as implant-grade PEEK, undergoes strict quality control to meet rigorous medical standards. This ensures its suitability for sensitive applications, though it is more expensive than industrial PEEK, where cost-effectiveness is prioritised over stringent quality controls.

While medical PEEK is used in implantable devices due to its biocompatibility and durability,

industrial PEEK is utilised in various industrial applications, valued for its high resistance to heat and chemicals. Despite being made from the same base material, the differences in manufacturing processes and applications distinguish medical PEEK from industrial PEEK.



## 3D printing with PEEK

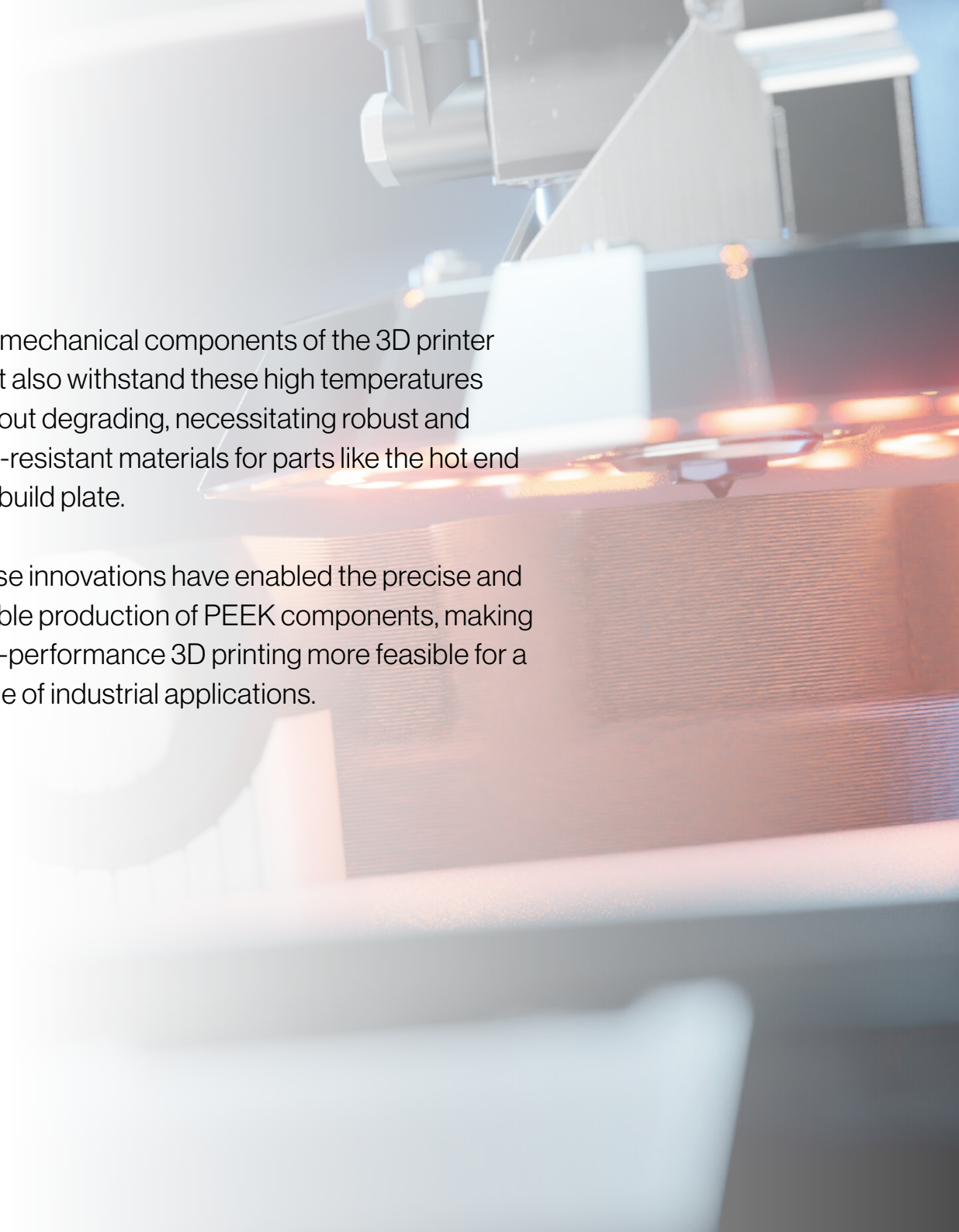
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3D printing with PEEK has evolved significantly, transitioning from traditional methods like Selective Laser Sintering (SLS) to the more accessible Fused Filament Fabrication (FFF) due to the development of PEEK filaments. SLS was initially used for PEEK due to its ability to handle the high temperatures required for processing this high-performance polymer. However, the advent of PEEK filaments has made FFF a viable option, broadening the accessibility of PEEK 3D printing.

Maintaining a uniform heat during the printing process is crucial to prevent warping and ensure strong inter-layer bonding. PEEK requires extrusion temperatures around 450°C, and the build chamber must be heated to maintain this environment.

The mechanical components of the 3D printer must also withstand these high temperatures without degrading, necessitating robust and heat-resistant materials for parts like the hot end and build plate.

These innovations have enabled the precise and reliable production of PEEK components, making high-performance 3D printing more feasible for a range of industrial applications.



## PEEK at the 3M BIC

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At the 3M BIC, we have Additive Manufacturing (AM) technologies that can print in PEEK materials.

### How we can help

#### **Short lead times**

quickly bring your ideas to life with reduced production times.

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#### **Agile experimental design**

enable multiple iterations and swift adjustments during the development process.

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#### **Complex part development**

design and produce intricate components with ease.

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#### **Engineered component optimisation**

fine-tune your designs for optimal performance.



### **R&D flexibility**

adapt prototypes and proof-of-concept models promptly, enhancing research and development efficiency.

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### **Seamless transition**

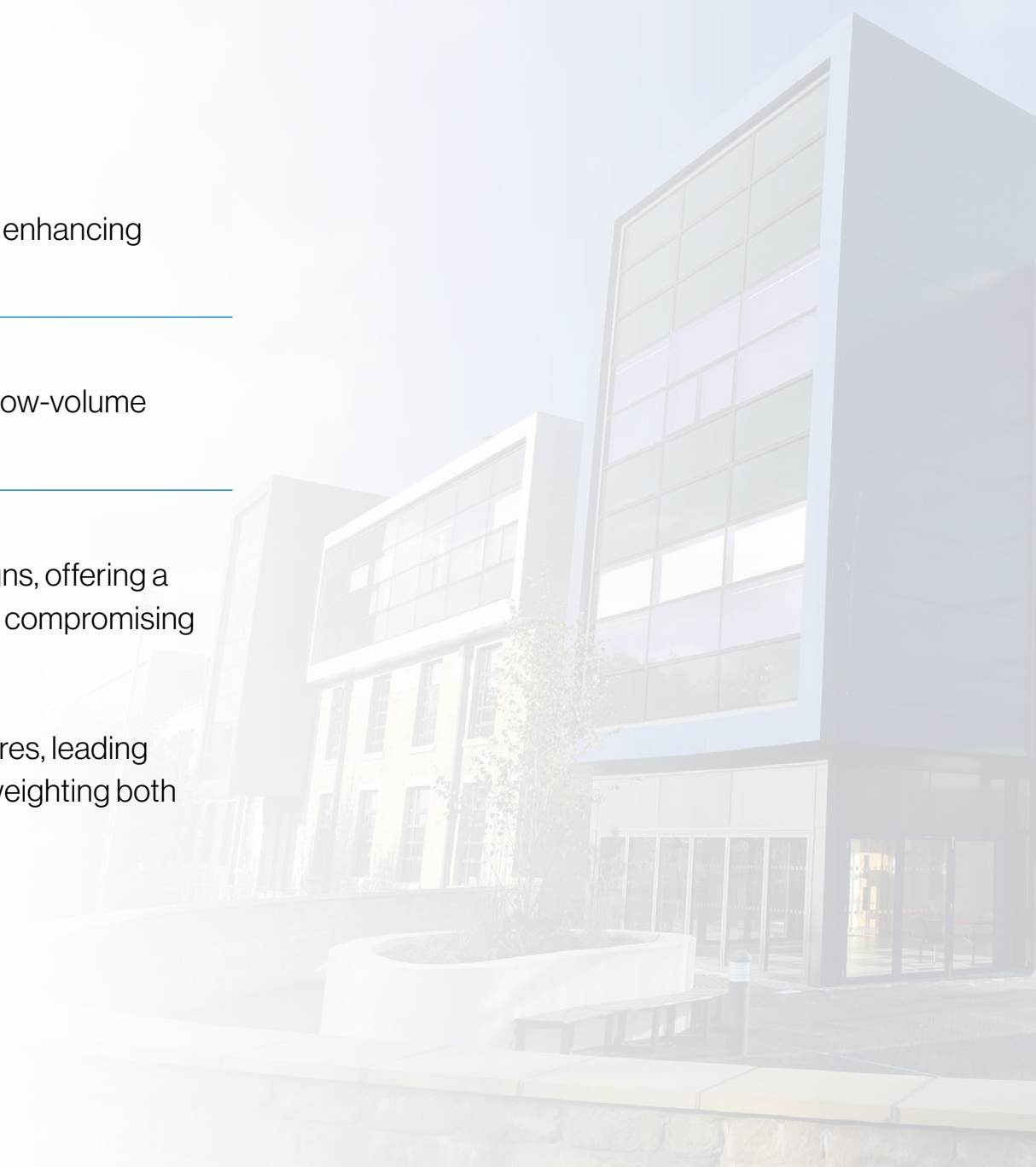
move smoothly from product testing to manufacturing or low-volume production

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### **Lightweight Solutions with AM PEEK**

Our PEEK capabilities allow us to create lightweight designs, offering a viable alternative to metals in various applications without compromising mechanical performance.

3D printed PEEK parts can also be made with infill structures, leading to material savings and reduced print times, making lightweighting both efficient and cost-effective.



## The future of PEEK

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The future of PEEK (Polyether Ether Ketone) in 3D printing looks incredibly promising, driven by its outstanding properties and the growing demand for high-performance materials.

As the technology for PEEK 3D printing continues to advance, we can expect a broader adoption across various industries.

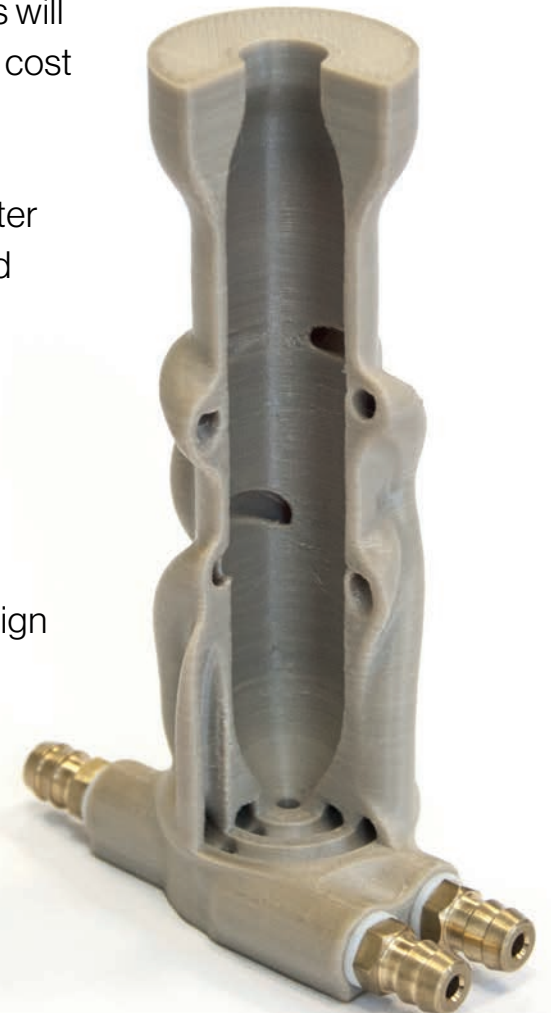
In the medical field, PEEK will likely become the standard for custom implants and devices due to its biocompatibility and ability to match the mechanical properties of human bone.

Aerospace and automotive sectors will benefit from PEEK's high strength-to-weight ratio and thermal stability, enabling the production of lightweight, durable components that enhance performance and fuel efficiency.

The ongoing development of more efficient and cost-effective 3D printing technologies will make PEEK more accessible, reducing the cost barriers associated with its use.

Innovations in filament production and printer capabilities will also improve the quality and reliability of PEEK prints, opening up new applications and markets.

PEEK's unique combination of properties positions it as a material of the future, with significant potential to revolutionise manufacturing processes and product design across multiple sectors.



# We'd love to hear from you!

Contact us today for more information.

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