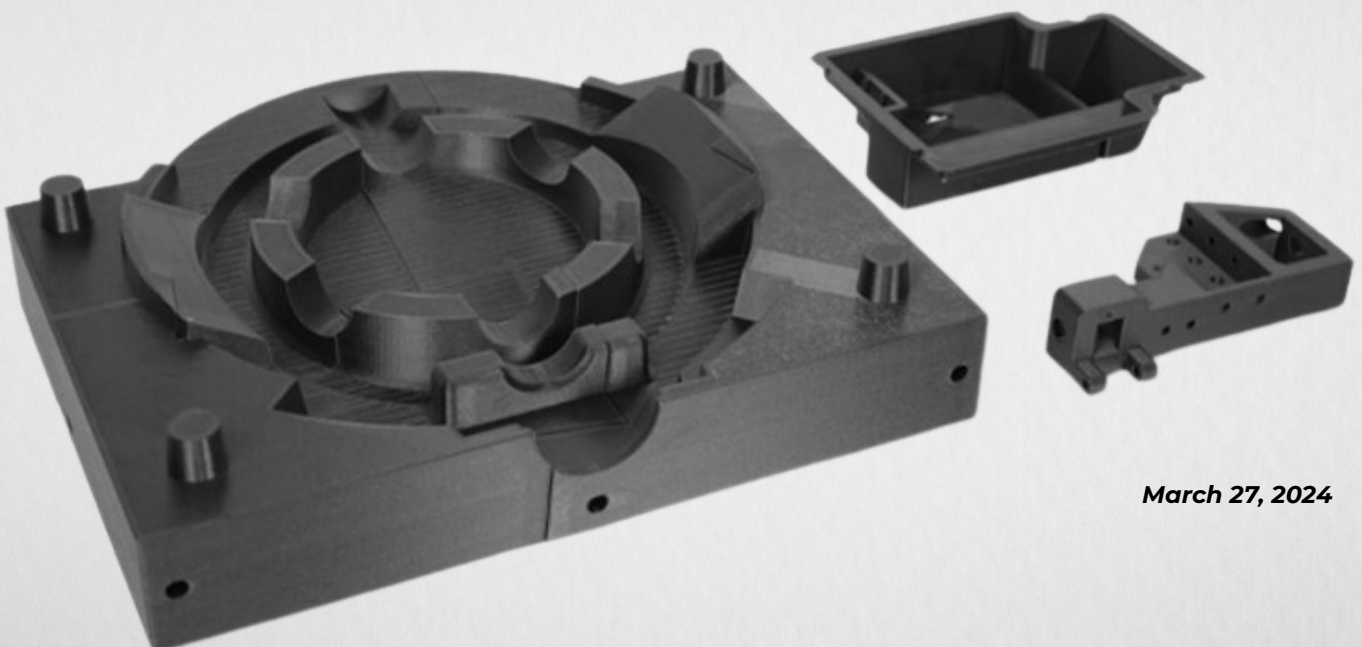




Raise3D Hyper Core **Filaments:** Revolutionizing High-Speed Composite Filament Printing

White Paper



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1 Introduction

- ▶ There is currently a critical demand for high-speed 3D printing utilizing Fused Filament Fabrication (FFF) technology. This innovation accelerates design iteration rates, shortens the product development cycle, enables efficient production of jigs and fixtures, and allows for low-volume production of end-use parts. In particular, high-speed 3D printing with composite materials, such as carbon fiber and fiberglass composites, stands to immensely benefit industries with higher performance needs such as automotive, aerospace, and electronics. The superior strength and heat resistance of these materials make them ideal candidates for advanced high-speed printing applications, enabling the creation of durable automotive parts, lightweight aerospace components, and heat-resistant electronic casings.

However, high-speed 3D printing presents numerous challenges, which become even more pronounced when printing with composite materials. Raise3D's newly launched Hyper Speed ABS filaments, Hyper Speed PLA filaments, and Hyper Core filaments were specifically designed to address these challenges, offering a solution that provides strength, durability, flexibility, and smooth surfaces, ideal for high-speed printing applications.

- ▶ In this white paper, we will first introduce Hyper FFF® high-speed printing technology and delve into the specific challenges associated with high-speed 3D printing, especially when it involves composite materials. We will then demonstrate how Hyper Core technology effectively addresses these challenges, supported by an in-depth examination of the material science underpinning Hyper Core filaments and accompanied by empirical evidence that substantiates our claims. To conclude, we will provide an overview of the current Hyper Core filament range and suggest practical applications for this transformative material.



2 Hyper FFF® Technology: Providing a High-Speed Foundation

- ▶ Raise3D's Hyper FFF® technology allows for printing speeds of up to 350 mm/s and increases print acceleration from 500-1,000 mm/s² to 5,000-10,000 mm/s² without compromising the quality of parts. This significant enhancement results from a holistic approach that integrates printer hardware, software, and materials.
- ▶ The development of Raise3D's Hyper FFF® technology included the creation of an anti-vibration cancellation algorithm. This algorithm calculates an optimized acceleration pattern and absorbs excess vibration occurring when the printer head makes high-speed directional changes.

By measuring the natural frequency of the extruder head, the processor splits the single acceleration command into two equivalent accelerations. This process generates two counteracting vibration waves, which effectively cancel out each other's vibration during the reversal phase. Consequently, the printer head significantly reduces its own friction and shaking while utilizing the same hardware.

- ▶ The Hyper FFF® upgrade facilitates printing speed improvements of up to 300%. However, at these enhanced speeds, the flow rate of conventional filaments could result in nozzle clogging and misprints. This posed the significant challenge: Developing a filament capable of melting and cooling swiftly enough to maintain high-quality prints at increased speeds. This challenge is what led to the creation of Hyper Speed thermoplastic filaments and Hyper Core filaments.

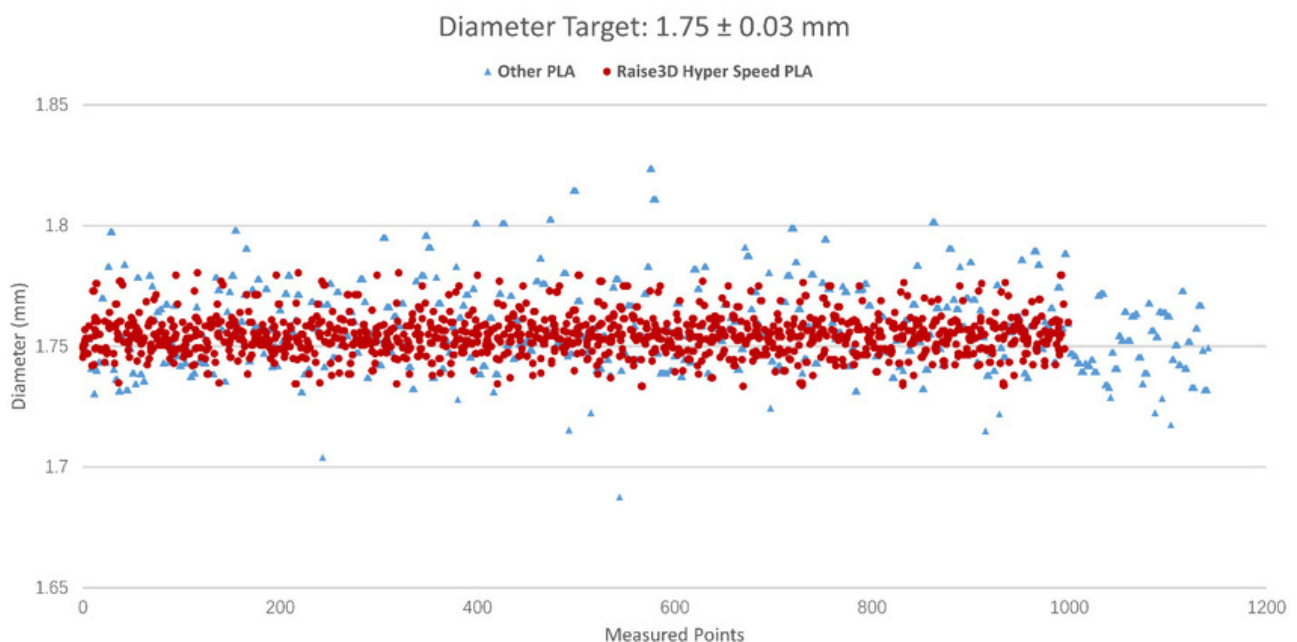


3 Raise3D High-Speed Filament Portfolio

- Raise3D's High-Speed filaments, including the **Hyper Speed ABS** and **Hyper Speed PLA** lines, along with the Hyper Core Carbon Fiber and Glass Fiber lines, have been developed to support Hyper FFF® printing without compromising print quality. Thanks to optimized molecular weight, increased flowability, and reduced heat capacity, Hyper Speed filaments melt and cool more rapidly; consequently, they maintain smooth surfaces and sharp details during high-speed printing.

Furthermore, Hyper Speed filaments provide printed parts with enhanced mechanical properties compared to traditional filaments used at high speeds. There is a noticeable improvement in the quality of interlayer bonding and impact resistance, resulting in printed objects that withstand more rigorous use and exhibit extended durability. This is particularly crucial for functional parts that necessitate a certain level of flexibility without sacrificing structural integrity.

In terms of filament quality, Hyper Speed filament lines maintain a consistent diameter and roundness when printing, ensuring uniform extrusion throughout the process. This consistency prevents issues that can arise from low quality filament, such as uneven layers or nozzle clogging.



- These data points collectively exhibit the superior qualities of High-Speed filaments compared to traditional filaments. Offering greater tensile strength, enhanced material properties, and improved filament quality and durability, these materials enable users to create prints that are not only produced faster but also more reliable and functional in their applications.

- ▶ Hyper Speed filament technology has proven to be extremely effective for non-composite thermoplastic filaments. However, stronger composite filaments have faced their own unique set of challenges that needed to be addressed to enable high-speed printing using Hyper FFF® technology.

4 Challenges of High-Speed 3D Printing Composite Filaments

- ▶ A major challenge of printing at high speeds, regardless of the material, is the “cold core” phenomenon. Heat from the printer's hot ends initially melts the outer perimeter of the filament, causing the outer skin to melt always before the inner core area. This phenomenon leads to a colder core that does not melt as uniformly, as quickly, or as homogeneously as the outer skin of the filament, creating an uneven thermal history of the extruded filament and resulting in deformed and delaminated prints.

Furthermore, composite filaments face their own unique challenges during high-speed printing. First, conventional fiber-reinforced composite filaments become highly viscous when melted, making them difficult to extrude from the printer nozzle and resulting in slow print speeds. Second, the fibers impair the quality of Z-axis interlayer bonding. Combined with the cold-core phenomenon, this bond becomes even less reliable, leading to decreased strength and durability in the final print.

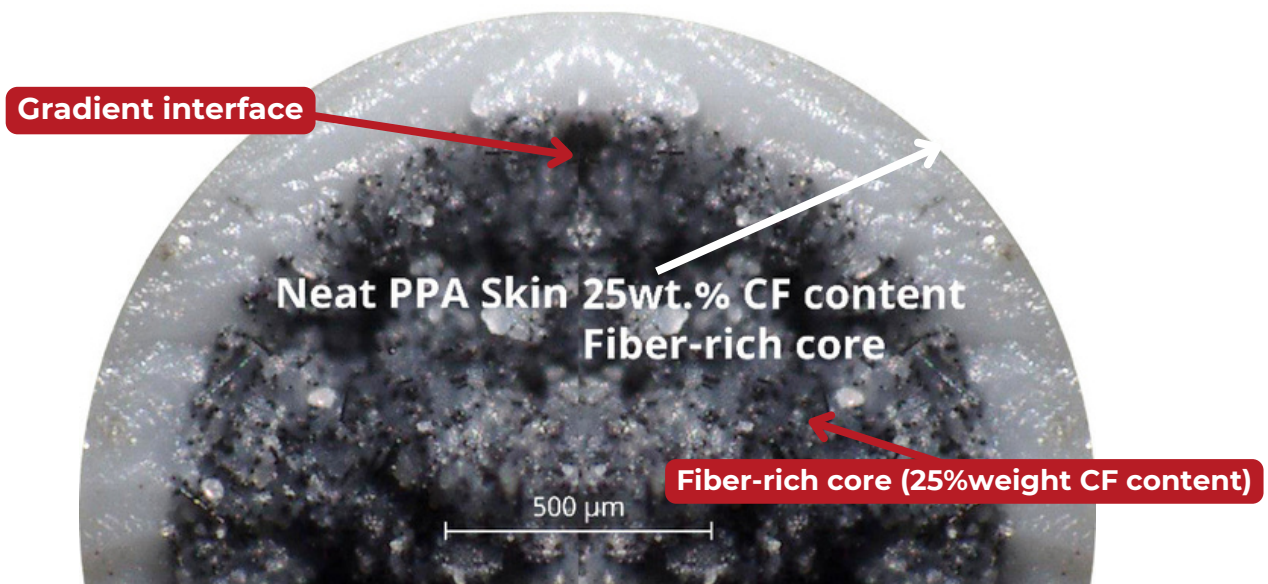
5 How Raise3D Hyper Core Filaments Solve Composite High Speed 3D Printing Challenges

- ▶ Hyper Core filaments achieve a balance between speed and output quality through a specialized filament and fiber configuration. By concentrating carbon or glass fibers near the filament's cross-sectional center (core) and surrounding them with an outer layer of matrix thermoplastic (skin), rather than dispersing them uniformly throughout the filament, the material around the fiber-rich core melts more efficiently and flows more quickly. The high conductivity of the filament's core facilitates more even melting compared to the slow melting typical of more homogeneous composite filaments. Combined with increased flowability due to a specially optimized Hyper FFF print head and nozzle, this promotes consistent flow and faster material deposition rates, which are crucial for maintaining the structural integrity of the object during high-speed printing. The outer layer of neat thermoplastic (skin) also protects the nozzle from being quickly abraded by carbon fibers or glass fibers.

As a result of this unique and tailored fiber distribution design, Hyper Core filaments melt and solidify more evenly than traditional composite filaments, delivering high-quality results even when printing at high speeds. This successfully addresses the challenges presented by the “cold core” phenomenon typical of conventional composite filaments.

6 Material Science Behind Raise3D Hyper Core Filaments

- ▶ Hyper Core’s polymer matrix is designed to have a lower melting temperature while also retaining high thermal stability. This dual characteristic ensures that the filament can quickly reach a state where it is malleable enough for extrusion without degrading under the intense heat associated with high-speed printing. The carbon or glass fibers embedded within the filament are also treated to enhance interlayer bonding with the matrix polymer, improving the overall structural integrity of the extruded material.
- ▶ The gradient interface between the carbon fiber- or fiberglass-rich core effectively creates a skin on the outer perimeter of the filament strand, serving as a conduit that improves the ductility and strength of the filament itself.



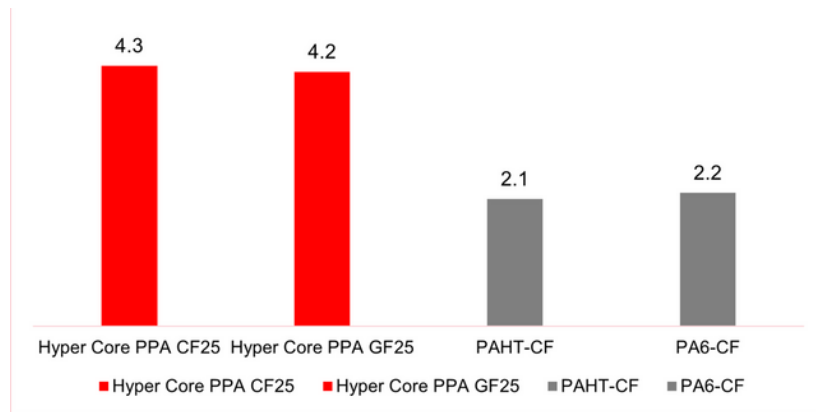
Raise3D Hyper Core PPA CF25

The interaction between the polymer and the fibers is tailored to facilitate a rapid yet controlled transition from solid to liquid state and back to solid. This rapid transition is crucial for Hyper FFF® high-speed printing, as it allows for swift layering without the delays typically associated with cooling and reheating. The precision in this chemical formulation results in a filament that not only melts evenly but also bonds with each layer and solidifies rapidly, ensuring that each layer is adequately supported as the next layer is applied.

Young's Modulus (GPa) of Composite Part Z-Axis

• All Hyper Core specimens were printed according to ISO 527-2 with printing speed of 300 mm/s

• Other composite filament sample data is from published TDS



As a result, Hyper Core materials printed at high speeds can handle significantly more strain than other composite materials printed at the same speeds, as shown in the above chart.

- ▶ Through its unique composite innovation, Hyper Core materials can tolerate the accelerated feeding speeds at the top of the extruder while maintaining the quality of the print all the way to the nozzle, making them ideal for applications that demand both speed and structural performance.

7 Family of Hyper Core Filaments

- ▶ The Hyper Core family of filaments offers a diverse range of materials, each tailored for specific applications and performance requirements. **Hyper Core PPA CF25** and **Hyper Core PPA GF25** are two examples, where CF denotes Carbon Fiber and GF stands for Glass Fiber. The numerical value indicates the percentage composition of these fibers within the filament.

Hyper Core PPA CF25 has a weight composed of 25% carbon fiber. This filament is designed for users requiring high strength and stiffness, making it suitable for parts needing to withstand a significant amount of weight. The carbon fibers not only enhance the tensile strength but also contribute to thermal stability, ensuring the parts can withstand temperatures without losing their structural integrity.

Hyper Core PPA GF25 has a weight composed of 25% glass fiber, and offers similar benefits to the CF variant but is optimized for slightly different applications. The glass fibers provide increased impact resistance, making this filament ideal for items that must endure repetitive stress or shocks. The material's inherent properties also include resistance to wear and a lower propensity for warping, thus ensuring dimensional stability post-printing.

Hyper Core ABS CF15 has a weight composed of 15% carbon fiber and is tailored for projects that demand the high durability of ABS with the added strength and rigidity of carbon fibers. This blend is advantageous for creating robust parts that also require a lighter weight, a common requirement in automotive and aerospace applications.



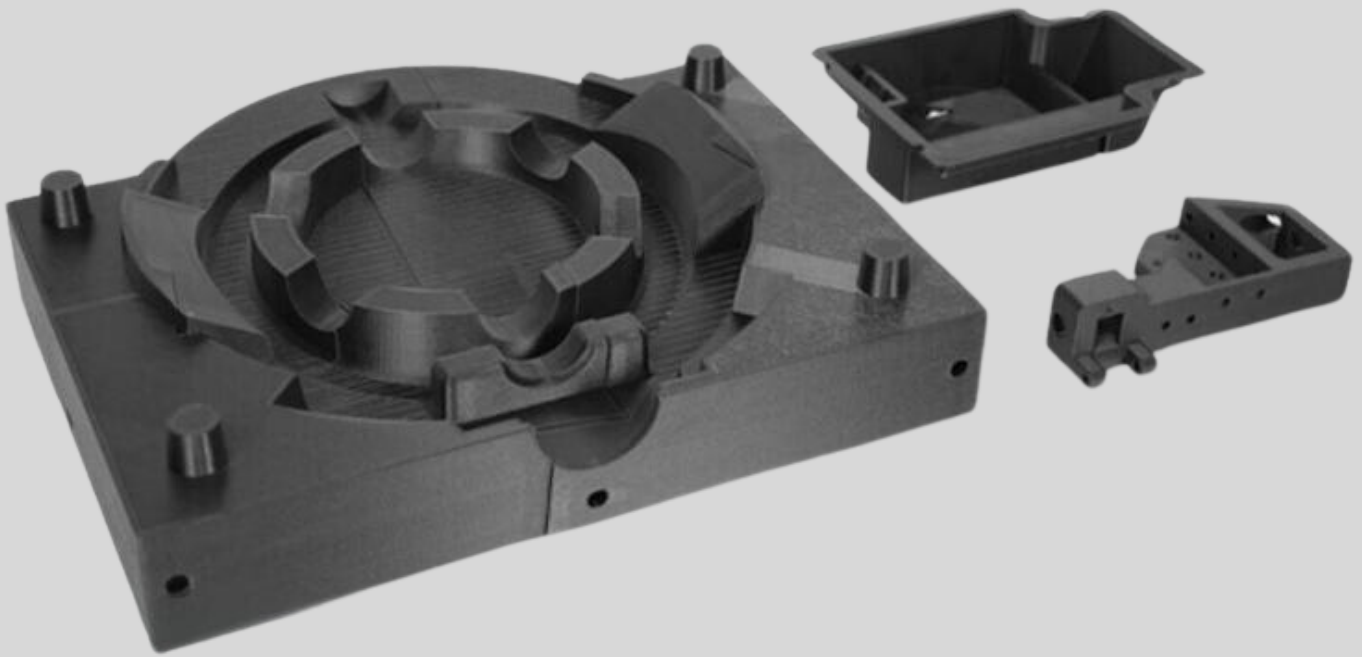
- Each filament in the Hyper Core family is developed to leverage the benefits of Hyper Speed printing technology, ensuring users can produce parts with superior mechanical properties, excellent surface quality, and high dimensional accuracy at speeds previously unattainable with standard materials.

8 Applications of Hyper Core Composite Filaments

- The applications of Hyper Core composite filaments span a wide array of industries, reflecting their versatility and advanced material properties. These materials are particularly suited for sectors where both the structural integrity of components and the speed of production are critical. Industries such as automotive and aerospace can significantly benefit from the superior performance characteristics of Hyper Core materials.
- In the automotive industry, for instance, Hyper Core filaments are utilized to produce complex end-use parts that must endure rigorous testing and operational stresses. The strength-to-weight ratio offered by materials such as **Hyper Core PPA CF25** is particularly valuable for manufacturing lightweight components that contribute to fuel efficiency and performance enhancements. Specific applications include creating durable engine components like intake manifolds and timing belt pulleys, aerodynamic parts such as front splitters and rear diffusers, and structural elements like seat frames and door mechanisms. Additionally, these filaments are ideal for crafting cooling system components, such as fan blades and coolant reservoir tanks, which require materials that withstand fluctuating temperatures. They are also used in interior features, such as ergonomic designs for dashboard components and connectors, enhancing aesthetics and comfort while maintaining low weight. Read our more about these applications [here](#).



- ▶ In aerospace applications, materials must exhibit high degrees of durability and thermal stability. **Hyper Core PPA GF25** filaments meet these requirements, providing essential resistance to impact and temperature variations crucial for aerospace components, while also enabling quicker production times, which facilitates faster prototyping and iterative design processes. Examples of applications include the production of interior cabin fixtures such as overhead bin latches and seat buckles that must withstand frequent use and variations in cabin pressure and temperature. They can also be used to create external non-load-bearing components like antenna covers and sensor mounts that face extreme environmental conditions. Additionally, these filaments are ideal for manufacturing detailed parts for HVAC systems in aircraft, which require materials that can handle both high pressures and temperatures. The rapid production capabilities of Hyper Core filaments support the aerospace industry's need for continuous improvement and testing of new designs and updates to existing models.
- ▶ Beyond these specific industries, Hyper Core composite materials can be adopted for a variety of custom manufacturing applications, from creating bespoke furniture to personalized medical devices. The ability to quickly print models and parts that are both accurate and robust opens up new possibilities for customization in manufacturing, offering both professionals and consumers new levels of product personalization.
- ▶ These applications demonstrate the broad potential of Hyper Core composite filaments to revolutionize manufacturing processes, providing high-quality, durable, and aesthetically pleasing products in a fraction of the time required by traditional methods.



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