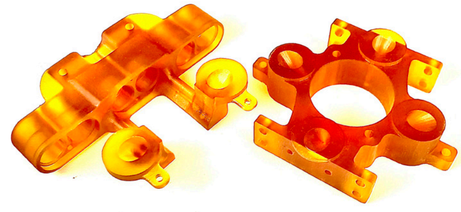
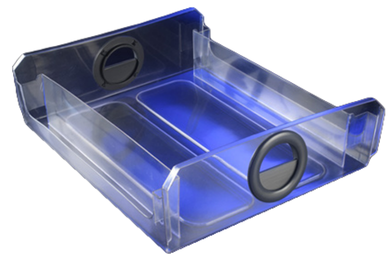




The Ultimate Guide to Polymer 3D Printing



THE TECHNOLOGY HOUSE

Your Guide to Successful Polymer 3D Printing

Our world has become a personalized, on-demand marketplace and additive manufacturing enables us to make more things faster and better than we could before. Materials have also advanced to where we can now use different types of engineered plastics and composites for prototyping and production.

Part finish has improved with automated post-processing, updated build prep software, new additive manufacturing equipment suppliers (like Carbon and HP), and the ability to create custom finishes and textures that are 3D printed directly onto your parts. With these vast improvements in technology, material, and part finish, 3D printed parts are not only strong enough to compete with the likes of machined and injection-molded parts, but they can look the part, too.

In this guide, you'll learn the ins and outs of polymer 3D printing and the processes that will help take your idea from concept to prototype to production.

Table of Contents

The Benefits of Polymer 3D Printing

Today, more companies in a wide range of industries are embracing polymer 3D printing technology due to the significant advantages it has over more traditional manufacturing methods, such as subtraction manufacturing and injection molding.

The main benefits of polymer 3D printing are realized in its cost, flexibility, and speed.

COST

Polymer 3D printing can be the most cost-effective manufacturing process for prototyping, small production runs and applications, and large custom production runs.

Traditional prototyping methods like CNC machining require costly machines, fixtures, and setups, while injection molding needs expensive metal tools with minimum order runs.

With polymer 3D printing, the ability to make complex shapes and parts more easily eliminates the high costs associated with programming and setups. Polymer 3D printing also allows you to make only what you need, minimizing material costs and minimum part orders—all while running unattended.

The Benefits of Polymer 3D Printing

DESIGN FLEXIBILITY

Polymer 3D printing allows you to design and print more complex geometries.

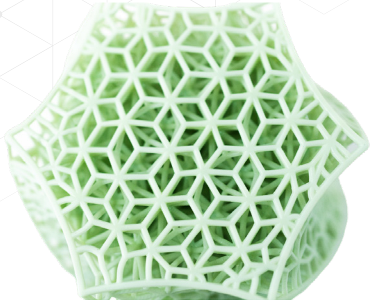
Traditional manufacturing methods often can't achieve this without incurring high costs and long lead times.

Some of the 3D printing technologies that can help you efficiently produce more complex geometries include:

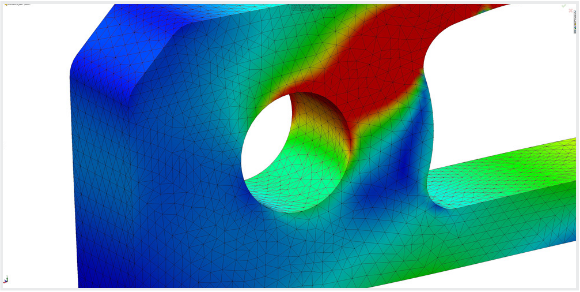
- **Lattice structures -** 3D additive printing allows you to create these repeating patterns, which connect to form three-dimensional shapes and open up many design possibilities. They can also be used to make parts lighter and stronger.
- **Finite element analysis (FEA) -** This computerized method anticipates real-world physical effects (like vibration, fluid flow, and heat) to understand whether a product will perform the way it's designed to perform.
- **Carbon Design Engine -** This innovative tool allows you to create performance-oriented lattice structure designs and go from idea to functioning part in just hours.

SPEED

You can save a lot of product development time and cost by using polymer 3D printing to iterate prototypes or go directly into printing production parts quickly. Polymer 3D printing is faster than traditional manufacturing methods because, unlike injection molding, no tooling is required to make parts. With polymer 3D printing, you can design a part, manufacture it, and test it, all within 24 hours.



Lattice Structure



Finite Element Analysis (FEA)

Bike Seat Made With Carbon Design Engine

The Types of Polymer 3D Printing Technology

There are several types of polymer 3D printing, which include:

- Micro Digital Light Processing (DLP)
- Carbon Digital Light Synthesis (DLS)
- Stereolithography (SLA)
- HP Multi Jet Fusion (MJF)
- Fused Deposition Modeling (FDM)
- Selective Laser Sintering (SLS)
- PolyJet

To select the right polymer 3D printing process for your application, it's important to understand the strengths of each process and map those attributes to your product development needs.

The Types of Polymer 3D Printing Technology

Micro Digital Light Processing (DLP)

For extremely precise, miniature parts

Micro DLP printing uses UV light to rapidly photopolymerize layers of resin. Unlike traditional DLP technologies that have resolutions between 75 and 100 microns, micro DLP prints parts at a resolution of 3.78 microns and with a layer thickness down to 1 micron.

Benefits of Micro DLP

- High-resolution
- Lower cost—no need for tooling
- Supports diverse applications
- Delivers unparalleled precision

Micro DLP is best used for:

- Prototypes
- Low-volume production parts
- As an alternative to traditional manufacturing
- Parts requiring high precision
- Parts with internal passageways

TTH's Micro DLP Equipment

Nano Dimension Fabrica Tera 250 Micro 3D Printer

The Fabrica Tera 250 allows us to deliver prototypes in five business days or less.

Key performance specs:

- Build envelope - 50 x 50 x 100 mm
- Build volume - 0.25 L
- Max resolution (XY) - 0.001 mm
- Max resolution (Z) - 0.001 mm

The Types of Polymer 3D Printing Technology

Carbon Digital Light Synthesis (DLS)

Carbon DLS allows for true 3D digital manufacturing

Carbon DLS is the photochemical process that uses both light and oxygen to build parts. DLS works by projecting UV images generated by a digital light projector through an oxygen-permeable window in a reservoir of UV-curable resin. After parts are built continuously in 75- to 100-micron layers, they go through a wash and rinse process. After all excess material is rinsed, supports are removed and parts go into either a thermal or UV oven for final curing, which gives the parts their mechanical properties and strengths.

Benefits of DLS

- Wide range of elastomeric and rigid engineering-grade materials
- Biocompatible and sterilizable materials
- Reduced time to market
- Isotropic parts, air-tight and leak-proof
- Outstanding surface finish
- Smart equipment for Industry 4.0

Carbon DLS is best used for:

- End-use production parts
- Digital inventory for on-demand
- production
- Part consolidation
- Complex, organic, generative designs

TTH's Carbon DLS Equipment

Carbon3D M2 Printer

The M2 can deliver quality parts in various materials at fast rates up to 20cm on the Z-axis per hour.

Key performance specs:

- Build envelope - 189 x 118 x 326 mm
- XY resolution - 75 µm
- Z resolution - 25, 50, or 100 µm
- Minimum layer height - 100 µm

Carbon3D M3 Max Printer

The M3 delivers next-generation DLS printing that can deliver fine, consistent finishes. It's the first 3D printer to leverage a 4K DLP light engine, which nearly doubles its build envelope without sacrificing resolution or print speed.

Key performance specs:

- Build envelope - 307 x 163 x 305 mm
- XY resolution - 75 µm
- Z resolution - 25, 50, or 100 µm

The Types of Polymer 3D Printing Technology

Stereolithography (SLA)

High-precision prototypes for your next development cycle

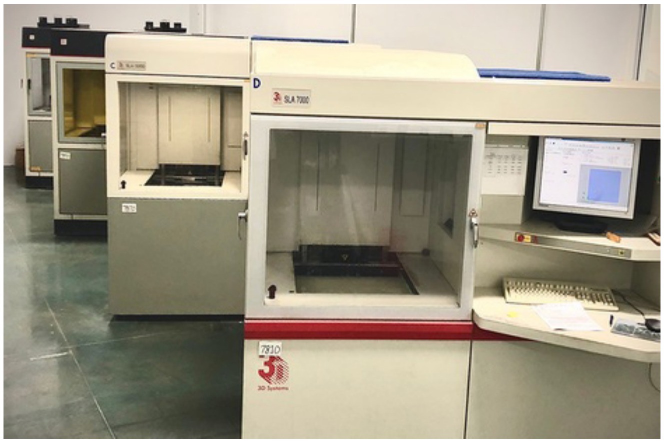
SLA is the process of converting a liquid plastic into solid, 3D objects using a stereolithograph apparatus, or SLA machine. SLA was the first additive manufacturing process and was introduced over 30 years ago. SLA works by building a 3D model of a component using a vat of liquid UV-curable photopolymer resin and an ultraviolet laser to form one thin layer at a time, usually 0.002"–0.006" or 50–150 microns thick

Benefits of SLA

- Highly accurate
- Smooth surface finish
- Easy to finish and paint
- Heat and moisture resistant
- Supports quick turnarounds
- Low costs with economies of scale

SLA is best used for:

- Fit and function samples
- Master patterns
- Painted sales and marketing samples
- Clear sample parts
- Quickcast for casting masters



The Types of Polymer 3D Printing Technology

HP Multi Jet Fusion (MJF)

Print production-quality parts with accurate and detailed part finish

HP MJF is a powder-based 3D printing process created by HP in 2016 for scaling industrial printing volumes from prototype to production. MJF is a digital manufacturing platform for additive manufacturing that 3D prints layers on top of molten layers, which allows the printed layers to fuse to form strong and detailed parts quickly. This allows MJF to produce production-quality parts with different materials faster than other similar technologies.

Benefits of MJF

- Strong, tough, and durable parts
- Fine feature resolution and surface finish
- Thermoplastic materials: Nylon, GF Nylon, PP, and TPU
- Economies of scale with fast, nested prints
- Isotropic mechanical properties
- Print complex organic shapes and working assemblies with no supports

MJF is best used for:

- Replacement parts
- Snap fits and living hinges
- End-use production of all volumes
- Air-tight and leak-proof parts
- Dying parts

TTH's MJF Equipment

HP Jet Fusion 5210 3D Printer

The 5210 can print a full build in approximately a half day or less and is perfect for all types of prototype and production projects.

Key performance specs:

- Build envelope - 380 x 284 x 380 mm
- Build volume - 41.01 L
- Z resolution - 0.08 mm
- Minimum layer height - 80 µm

The HP Jet Fusion 5420W Printer

The 5420W delivers white consistency, uniformity, and repeatability. It's ideal for applications and markets that require engineering-grade white production parts (e.g., medical devices and consumer goods).

Key performance specs:

- Build envelope - 380 x 284 x 380 mm
- Minimum layer height - 0.09 mm

The Types of Polymer 3D Printing Technology

Fused Deposition Modeling (FDM)

The most common and one of the most affordable 3D printing processes

FDM is the most widely used 3D printing process because of its ease of use and ability to run real engineered plastics. Also known as fused filament fabrication (FFF), FDM is a popular method for additive manufacturing but has its specific benefits. FDM is more widely known and affordable than HP MJF or Carbon DLS due to the availability and low cost of entry with desktop 3D printers.

Benefits of FDM

- Tough and durable parts
- Real thermoplastic materials: ABS, PC, Nylon, and Ultem
- Sustainable
- Ease of use
- Low cost

FDM is best used for:

- Jigs and fixtures
- Strong prototypes
- Low-volume production
- Material and durability testing
- Part replacements

The Types of Polymer 3D Printing Technology

Selective Laser Sintering (SLS)

Tough and durable prototype and production parts from thermoplastic material

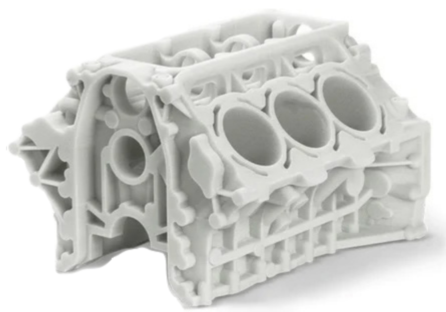
SLS is the 3D printing process of creating 3D objects with an expensive laser and plastic powders. SLS is very similar to the SLA process in that it uses a laser to make a 3D object. However, it uses powder material instead of liquid material. Also, similar to HP MJF, SLS can build a whole chamber of parts at the same time without support.

Benefits of SLS

- Tough and durable parts
- Thermoplastic materials (Nylon and GF Nylon)
- Economy of scale prints
- Print working assemblies
- Heat resistant
- UL94 rated
- Biocompatible

SLS is best used for:

- Material testing
- End-use production parts
- Durable housings
- Snap fits
- Living hinges



The Types of Polymer 3D Printing Technology

PolyJet

The ideal process for 3D printing multi-material prototypes and highly complex parts with many fine details

PolyJet is an inkjet process for 3D printing that creates smooth and accurate parts. Movie effects, medical models, consumer goods, automotive parts, and electronic components are typical applications for PolyJet parts.

PolyJet works by simultaneously jetting drops of photopolymer materials that solidify when exposed to UV light. This is repeated in microscopic layers until the part and the build is complete. Multiple materials and/or colors can be jetted at the same time to create multi-material or multi-colored printed parts. The result is a solid 3D model.

Benefits of PolyJet

- Highly accurate with fine details
- Smooth finish
- Ease of use
- Multi-materials (e.g., over-mold samples)
- Multi-colored
- Economy of scale

PolyJet is best used for:

- Design checks
- Rapid tooling
- Full-color marketing models
- Full-color figurines
- Medical models
- Over-molded samples

Post-Processing Options

Depending on your application's requirements, there is a range of different finishes and coatings for prototype and production parts. Most polymer 3D printed parts require a level of finishing.

Plastic Part Finishes

- Tumbling
- Vapor smoothing
- Media blasting
- Inserts and assembly
- Drill, ream, and machine
- Painting (flat to gloss)
- Color-match paints
- Clear (frost, tint, and dye)
- Dyeing
- Textures (printed and post-print)
- Vacuum metalize
- Plating
- EMI shielding
- Soft-touch coatings
- PTFE coatings
- Part decorations (e.g., labels and decals)

Polymer 3D Printing FAQs

Q: Can I finish and paint polymer 3D printed parts?

A: Yes! Each process is a little different, but you can create custom finishes on your parts. At TTH, we offer a range of finishes, including clear, painted (matte, gloss, etc.), texture, labels, metalizing, and plating. Most processes do require some sanding to remove the build layer lines if you want to get show or production finish quality.

Q: Should I print threads or use inserts?

A: This depends on the material and process you use, but we recommend using heat-staked inserts whenever possible to ensure a great threaded fit between your part and the screw. If you need threads in your part, we recommend printing the threads in the parts. We will then chase the threads during finishing to ensure they work.

Q: Rapid prototyping vs. polymer 3D printing: What's the difference?

A: Polymer 3D printing, or additive manufacturing, is the process of building parts by joining polymer material layer by layer from a CAD file. This is unlike a traditional manufacturing process, like CNC machining, where a part is built by subtracting material from a block of material. Polymer 3D printing and additive manufacturing can be used regardless of whether the parts are fabricated in plastic or rubber.

Rapid prototyping is the technique of fabricating a prototype model from a CAD file. In other words, polymer 3D printing/additive manufacturing is the process and rapid prototyping is the result. Rapid prototyping is also used to describe any prototype parts that are needed ASAP, including urethane casting, injection molding, and CNC machining. Polymer 3D printing is just one of many applications under the rapid prototyping umbrella.

Q: What file format do I need to fabricate my parts?

A: The process of polymer 3D printing begins with a 3D CAD model. After the 3D model is created, it's exported as STEP, IGES, and Parasolid files. An STL file can then be exported from these file formats. If an STL file isn't available, multiple engineering programs can be used to export an STL file. The most common programs are Catia, SolidWorks, and Creo (ProE).

Polymer 3D Printing FAQs

Q: How large can you make polymer 3D printed parts?

A: Technically, you can build a part of any size. This is due to polymer 3D printing's ability to make parts in sections. Using the latest 3D printing software, TTH can create special cut patterns, like puzzle pieces, to seamlessly align and bond parts back together during the post-processing. We have made parts as large as six feet in diameter.

Q: Can you glue 3D printed parts?

A: Yes. It is very common to section and bond parts in 3D printing to make large parts or fix those prototypes that may get chipped over time. We usually use super glue or a Loctite two-part epoxy.

Q: What is the minimum thickness required?

A: The minimum thickness can vary based on the material, machine, and process, but most processes require a minimum thickness of .025" to .030". Softer materials will require a thickness of at least .040". Smaller features, walls, and geometries can be built but are geometry or build orientation-dependent. Keep in mind that most 3D printing processes require some finishing and small, thin features are more delicate and take a lot of care to survive printing, processing, and shipping.

Q: What tolerances are 3D printers capable of holding?

A: Tolerances are a function of the process, material, geometry, and overall size of the part. Here is TTH's standard tolerancing:

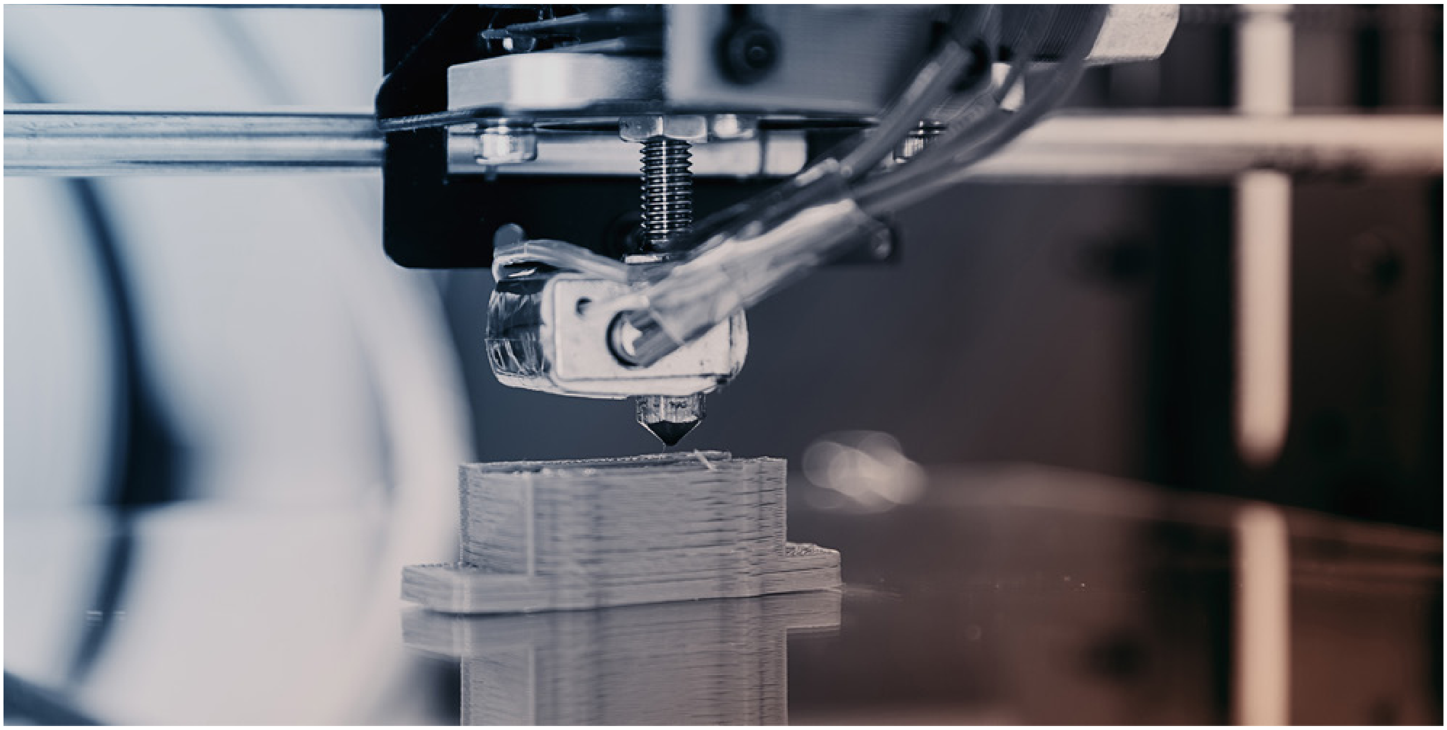
- Carbon DLS, FDM, Polyjet, SLA, and SLS 3D printing tolerances are +/- 0.005" for the first inch and +/- 0.002" per inch thereafter. (Z plane starts at +/-0.010" for the first inch).
- HP MJF 3D printing tolerances are +/- .010" for the first inch and +/- .003" for each inch thereafter.
- Guaranteed tolerances are confirmed on a case-by-case basis.
- Flat parts, thick parts, and uneven wall thicknesses can cause deviations and warp, which can make tolerancing difficult to hold.
- Most tolerances can be improved with multiple builds used to build shrink into the files to optimize each build, similar to "dialing" in a CNC machine or injection mold press

Polymer 3D Printing FAQs

Q: In what ways can I reduce polymer 3D printing costs?

A: There are multiple ways to save on polymer 3D printing and additive manufacturing costs. Here are the most common:

- Hollow out or use sparse build files to reduce material and build times
- Consolidate parts when possible to reduce material and part counts
- Tall parts can be cut and run in sections to be bonded in finishing
- Use larger build layers to decrease build times (this will reduce part quality finish)
- Nest or group parts together to reduce overall costs through economies of scale
- Run a topology optimization to improve the design of the product
- Design for the additive process to ensure parts are easier to clean and remove from the build platform



Your Full-Service Partner for Polymer 3D Printing

Ready to find the right polymer 3D printing solution for your project?

At TTH, we specialize in creating custom, intricate polymer 3D printed parts for demanding industries. From design through prototyping and production, our integrated, all-under-one-roof approach allows you to take your concept to market faster and more cost-effectively.

Contact Us

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