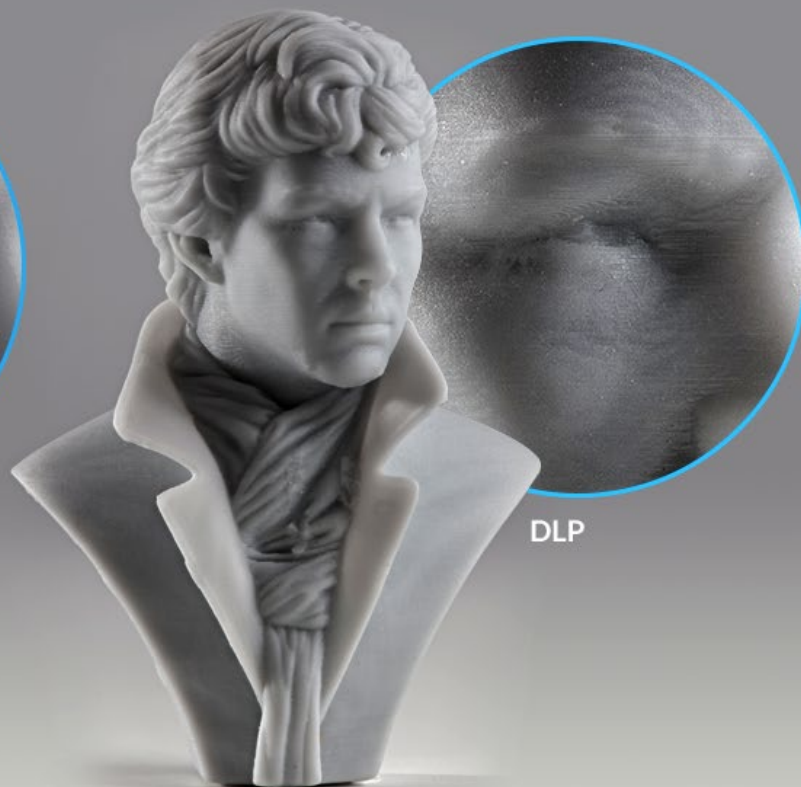


SLA



DLP

WHITE PAPER

SLA vs. DLP

Compare Resin 3D Printing Technologies

Stereolithography (SLA) and digital light processing (DLP) 3D printing are the two most common processes for resin 3D printing. In this in-depth guide, we walk through the details of each technology and explore how they compare in terms of resolution, accuracy, build volume, speed, workflow, and more.

Contents

Introduction	3
How Do SLA 3D Printers Work?	4
How Do DLP 3D Printers Work?	6
SLA vs. DLP: Side by Side Comparison	7
Get Started With SLA 3D Printing	14

Introduction

There are many 3D printing processes on the market. Getting familiar with the nuances of each helps to clarify what you can expect from final prints to ultimately decide which technology is suitable for your particular application.

SLA and DLP 3D printers are popular for producing high-accuracy, isotropic, and watertight prototypes and parts in a range of advanced materials with fine features and smooth surface finish.

While these technologies were once complex and cost-prohibitive, today's small-format desktop SLA and DLP 3D printers produce industrial-quality parts at an affordable price point and with unmatched versatility thanks to a wide range of materials.

Both processes work by selectively exposing liquid resin to a light source—SLA a laser, DLP a projector—to form very thin solid layers of plastic that stack up to create a solid object.

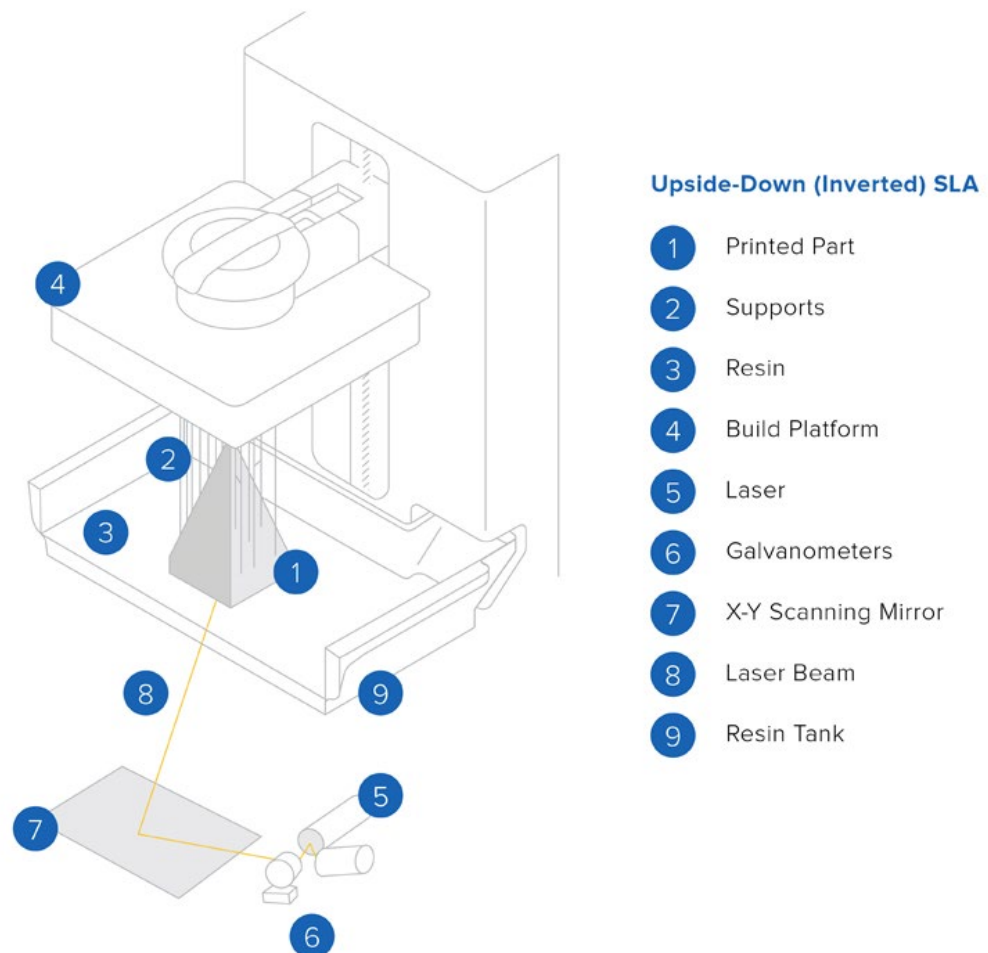
While very similar in principle, the two technologies can produce significantly varying outputs.

How Do SLA 3D Printers Work?

Desktop SLA 3D printers contain a resin tank with a transparent base and non-stick surface, which serves as a substrate for the liquid resin to cure against, allowing for the gentle detachment of newly-formed layers.

The printing process starts as the build platform descends into a resin tank, leaving space equal to the layer height in between the build platform, or the last completed layer, and the bottom of the tank. A laser points at two mirror galvanometers, which direct the light to the correct coordinates on a series of mirrors, focusing the light upward through the bottom of the tank and curing a layer of resin.

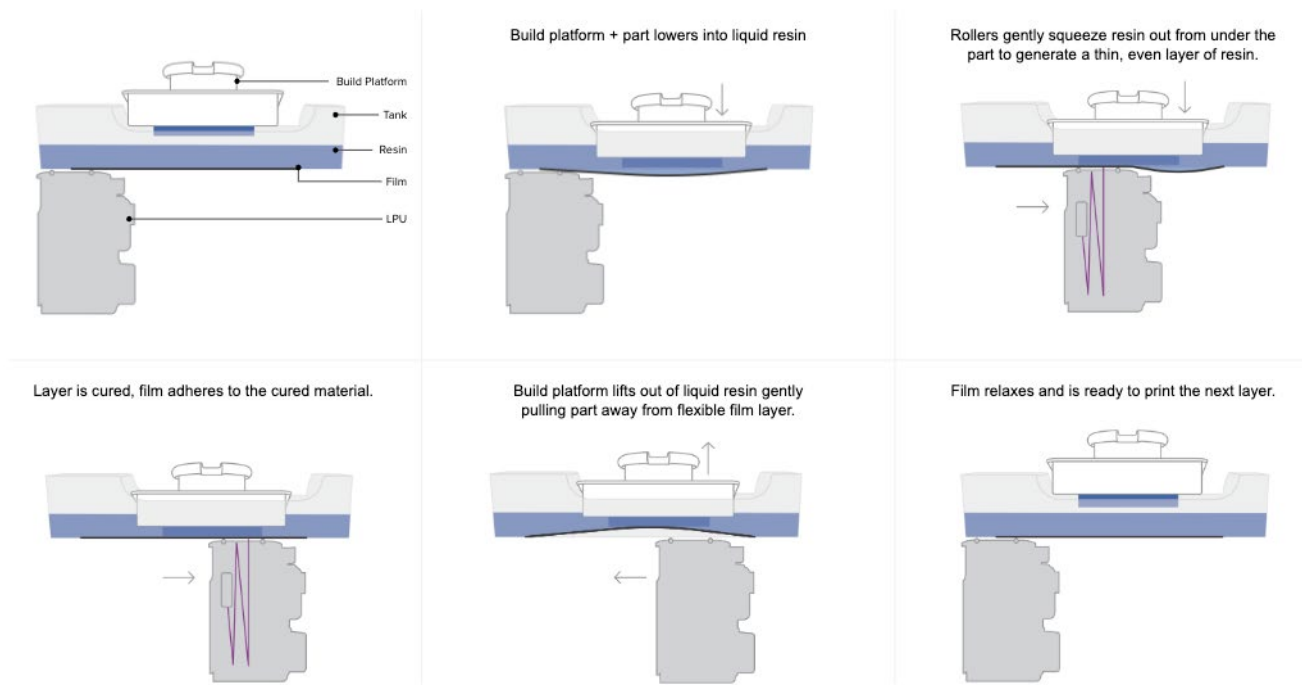
The cured layer then gets separated from the bottom of the tank and the build platform moves up to let fresh resin flow beneath. The process repeats until the print is complete.



Low Force Stereolithography (LFS) technology, used by the Form 3 and Form 3L, is the next phase in SLA 3D printing.

In LFS 3D printers, the optics are enclosed in a Light Processing Unit (LPU). Within the LPU, a galvanometer positions the high-density laser beam in the Y direction, passes it through a spatial filter, and directs it to a fold mirror and parabolic mirror to consistently deliver the beam perpendicular to the build plane and ensure accurate, repeatable prints.

As the LPU moves in the X direction, the printed part is gently peeled away from the flexible bottom of the tank, which drastically reduces the forces exerted on parts during the print process.

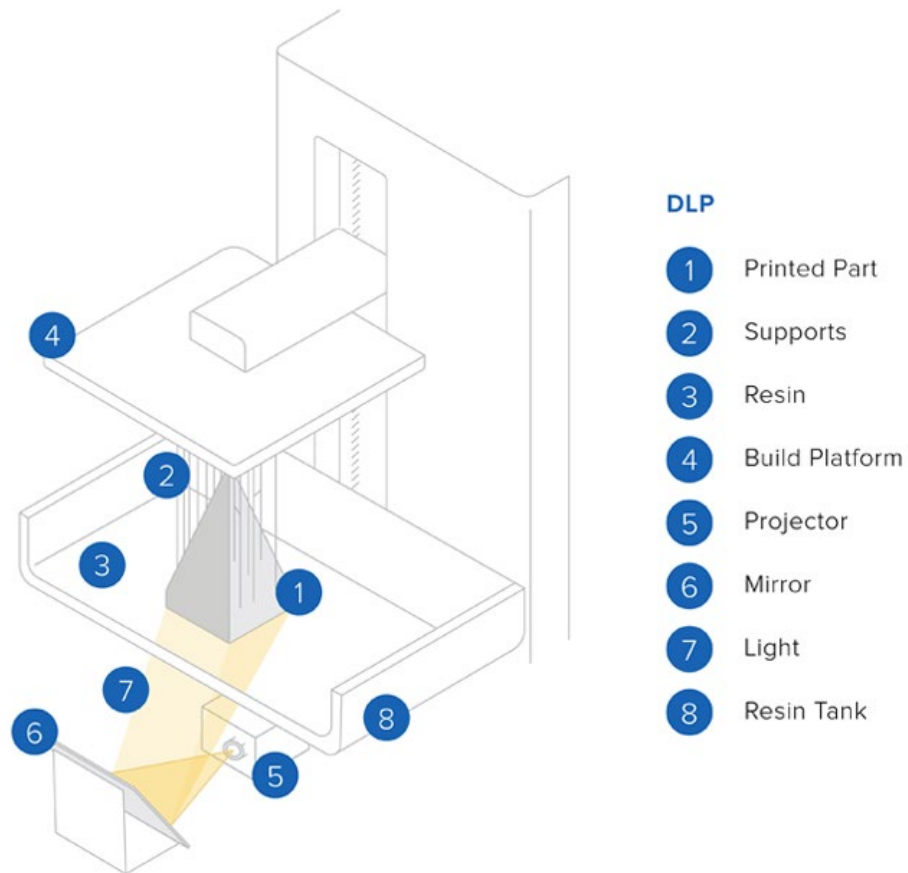


LFS 3D printing drastically reduces the forces exerted on parts during the print process, using a flexible tank and linear illumination to deliver incredible surface quality and print accuracy

This advanced form of stereolithography delivers vastly improved surface quality and print accuracy. Lower print forces also allow for light-touch support structures that tear away with ease, and the process opens up a wide range of possibilities for future development of advanced, production-ready materials.

How Do DLP 3D Printers Work?

Just like their SLA counterparts, desktop DLP 3D printers are built around a resin tank with transparent bottom and a build platform that descends into a resin tank to create parts upside down, layer by layer.



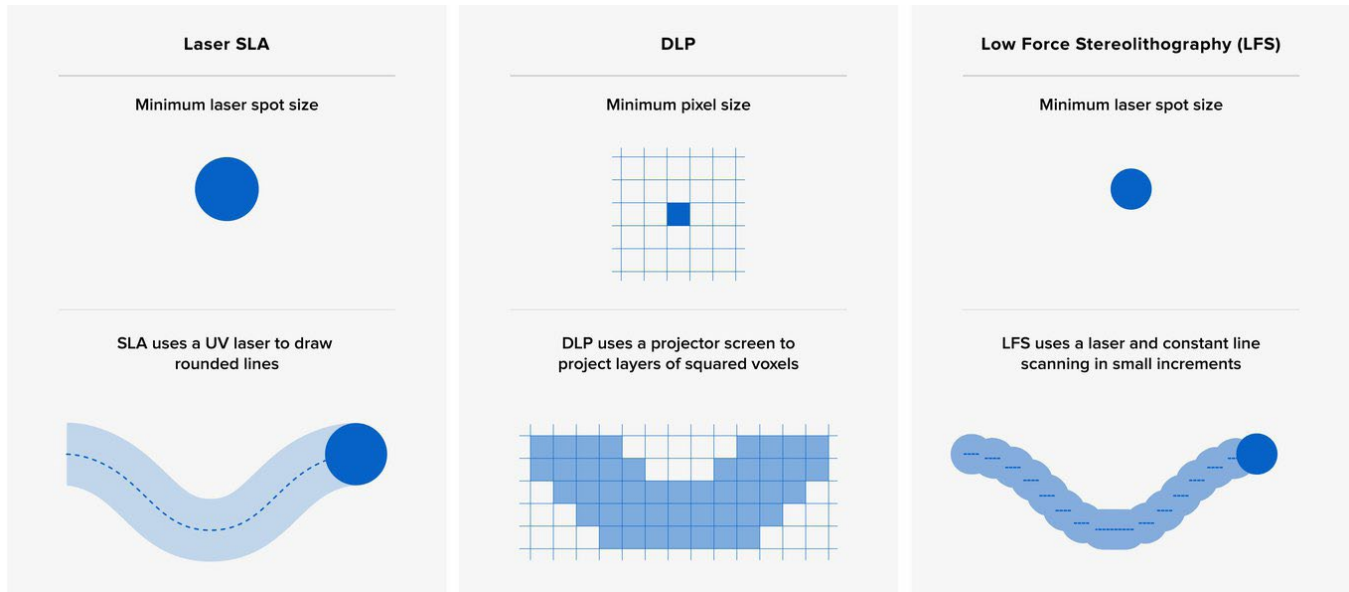
The difference is the light source. DLP 3D printers use a digital projector screen to flash an image of a layer across the entire platform, curing all points simultaneously.

The light is reflected on a Digital Micromirror Device (DMD), a dynamic mask consisting of microscopic-size mirrors laid out in a matrix on a semiconductor chip. Rapidly toggling these tiny mirrors between lens(es) that direct the light towards the bottom of the tank or a heat sink defines the coordinates where the liquid resin cures within the given layer.

Because the projector is a digital screen, the image of each layer is composed of square pixels, resulting in a three-dimensional layer formed from small rectangular cubes called voxels.

SLA vs. DLP: Side by Side Comparison

Resolution



Resolution shows up more often than any other value in 3D printer spec sheets, but it's also a common ground for confusion. The basic units of the SLA and DLP processes are different shapes, making it difficult to compare the different machines by numerical specifications alone.

In 3D printing, there are three dimensions to consider: the two planar 2D dimensions (X and Y) and the third vertical Z dimension that makes 3D printing.

Z resolution is defined by the layer thicknesses a 3D printer can produce. SLA and DLP both offer some of the finest Z resolutions—thinnest layers—of all 3D printing processes and users can normally choose from a range of layer height options between 25-300 microns, allowing designers to strike a balance between detail and speed.

In DLP 3D printing, XY resolution is defined by the pixel size, the smallest feature the projector can reproduce within a single layer. This depends on the resolution of the projector, the most common being full HD (1080p), and its distance from the optical window. As a result, most desktop DLP 3D printers have a fixed XY resolution, generally between 35 to 100 microns.

For SLA 3D printers, XY resolution is a combination of the laser's spot size and the increments by which the laser beam can be controlled. For example, the Form 3 LFS 3D printer features a laser with an 85 micron spot size, but because of the constant line scanning process, the laser can move in smaller increments and the printer can consistently deliver parts with 25 micron XY resolution.

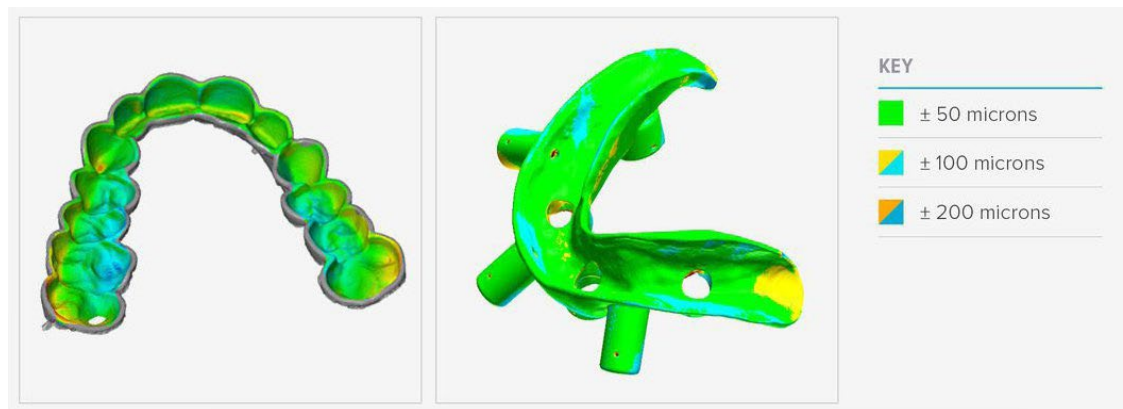
However, resolution in itself is often just a vanity metric. It offers some indication, but it doesn't necessarily correlate directly with accuracy, precision, and print quality.

Accuracy and Precision

Because 3D printing is an additive process, each layer introduces an opportunity for inaccuracy, and the process by which layers are formed affects the level of precision, defined as the repeatability of the accuracy of each layer. Accuracy and precision depend on many different factors: 3D printing process, materials, software settings, post-processing, and more.

In general, both SLA and DLP resin 3D printers are among the most accurate and precise 3D printing processes. Differences in accuracy and precision are often better explained by the differences between machines by various manufacturers than differences between the technologies themselves.

For example, entry-level SLA or DLP printers might use off-the-shelf projectors, lasers, or galvanometers, and their manufacturers will try to get the best performance possible out of these parts. Professional SLA and DLP 3D printers, like the Formlabs Form 3, feature a custom optical system adapted to the specifications required by professional customer applications.



Accuracy and precision are crucial for parts like dental splints (left) and surgical guides (right).

Calibration is also crucial. With DLP projectors, manufacturers need to deal with the non-uniform light distribution on the build plane and optical distortion of the lenses—meaning that pixels in the middle are not the same size or shape as pixels on the edges. SLA 3D printers use the same light source for every part of the print, which means it's uniform by definition, but they still require extensive calibration to account for distortions.

Even a 3D printer with the highest quality components and degree of calibration can produce widely varying results depending on the material. Different resins require optimized material settings to perform as intended, which might not be available for off-the-shelf materials or resins that are not thoroughly tested with a specific 3D printer model.

The takeaway? Accuracy and precision are almost impossible to understand from the technical specifications alone. Ultimately, the best way to evaluate a 3D printer is to inspect real parts or ask the manufacturer to create a test print of one of your own designs.

Build Volume

With DLP 3D printers, there's a direct trade-off between resolution and build volume. The resolution depends on the projector, which defines the number of pixels/voxels available. If one moves the projector closer to the optical window, the pixels get smaller, which increases the resolution, but limits the available build area.

Some manufacturers stack multiple projectors next to each other or use a high-definition 4K projector to increase the build volume, but this leads to substantially higher costs that often price these machines out of the desktop market.

As a result, DLP 3D printers are generally optimized for specific use cases. Some have a smaller build volume and offer high resolution to produce small, detailed pieces like jewelry, while others can produce bigger parts but at a lower resolution.

SLA systems are inherently more scalable, since an SLA 3D printer's build volume is completely independent of the resolution of the print. A single print can be any size and any resolution at any location within the build area. This makes it possible to 3D print large parts at high resolution or a large batch of detailed small parts to increase throughput with the same machine.

The other main barrier to increasing build volume in both SLA and DLP 3D printers is the peel force. When printing larger parts, the forces exerted on the parts increase exponentially as a cured layer separates from the tank.

In LFS 3D printing, the flexible film at the base of the resin tank gently peels away as the build platform pulls the part up, significantly reducing the stress on the part. This unique feature has made it possible to substantially increase the build volume for the first accessible large format SLA 3D printer, the Form 3L.

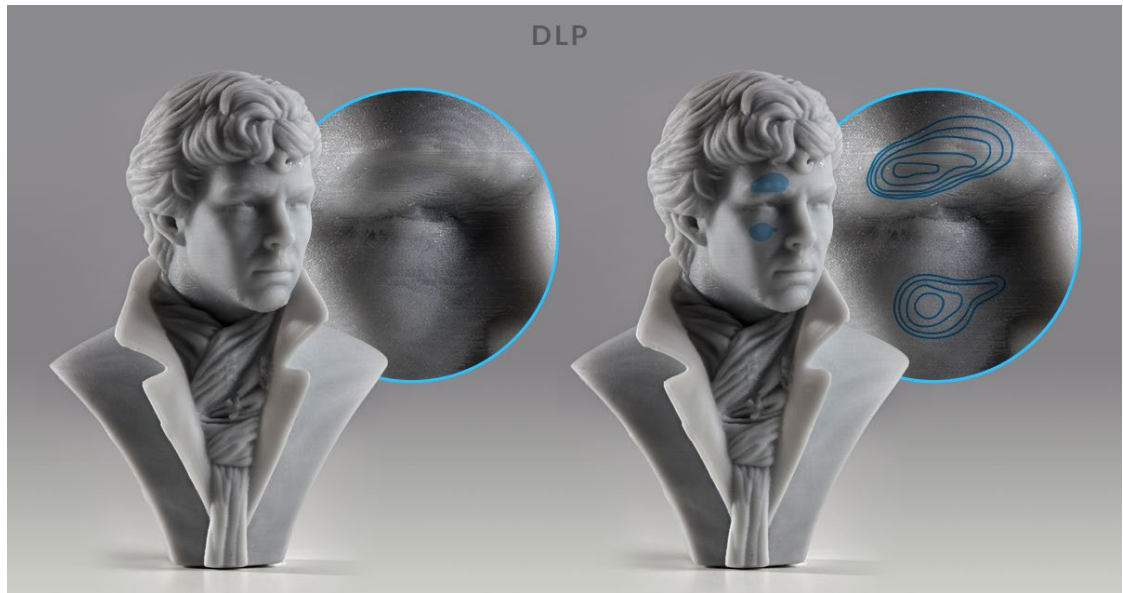
The Form 3L is the first affordable large format SLA 3D printer with a build volume of 30 cm x 33.5 cm x 20 cm.



Surface Finish

SLA and DLP resin 3D printers both known for creating parts with the smoothest surface finish of all 3D printing processes. When we describe the differences, in most cases these are only visible on tiny parts or highly detailed models.

Because objects are made of layers in 3D printing, 3D prints often have visible, horizontal layer lines. However, because DLP renders images using rectangular voxels, there is also an effect of vertical voxel lines.

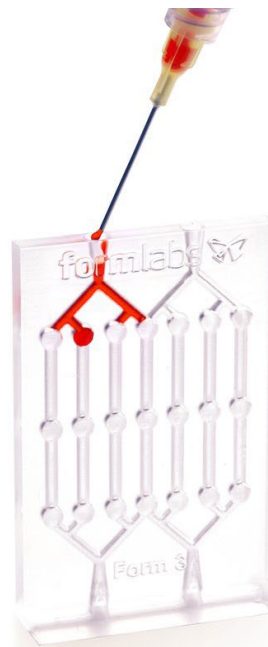


DLP 3D printers render images using rectangular voxels, which causes an effect of vertical voxel lines. In this image, see the vertical voxel lines as they appear naturally on the left, and then outlined to more easily identify on the right.

Because the unit is rectangular, voxels also have an effect on curved edges. Think of building a round shape out of LEGO bricks—the edges will appear stepped on both the Z axis and the X-Y plane.



The rectangular shape of voxels makes curved edges appear stepped. Removing the appearance of voxel and layer lines requires post-processing, such as sanding.



In LFS 3D printing, layer lines are close to invisible. As a result, surface roughness is reduced, which ultimately leads to a smooth surface finish, and for clear materials, more translucent parts.

Speed and Throughput

When thinking about speed in 3D printing, it's important to consider not just raw print speed, but also throughput.

Raw print speed for SLA and DLP resin 3D printers is comparable in general. As the projector exposes each entire layer all at once, print speed in DLP 3D printing is uniform and depends only on the height of the build, whereas, SLA 3D printers draw out each part with a laser. As a rule of thumb, this results in SLA 3D printers being comparable or faster when printing small or medium-size single parts, while DLP 3D printers are faster to print large, fully dense prints, or builds with multiple parts that fill up much of the platform.

But once again, it's worth considering the trade-off between resolution and build volume for DLP printers. A small DLP 3D printer can print a small part or a (small) batch of smaller parts fast, at high resolution, but the build volume limits the part size and the throughput. A different machine with a larger build volume can print larger parts or a batch of smaller parts faster, but at a lower resolution than SLA.

SLA 3D printers can produce all of these options in one machine and offer the user the freedom to decide whether she wants to optimize for resolution, speed, or throughput.



SLA 3D printers offer a larger build volume, allowing users to batch parts and print overnight to increase throughput.



Resin 3D printers offer a variety of materials for a wide range of applications.

Workflow and Materials

Just like with accuracy and precision, the workflow and available materials differ more from machine to machine than technology to technology.

Most SLA and DLP printers are “plug and play,” with easily swappable build platforms and resin tanks. Some more advanced models also come with a cartridge system to automatically refill the tank with liquid resin, which requires less attention and facilitates printing overnight.

Some printers come with proprietary software to prepare 3D models for printing, such as PreForm for Formlabs SLA 3D printers, while other manufacturers offer off-the-shelf solutions. Features differ by software tool, for example, PreForm offers one-click print setup, powerful manual controls to optimize support density and size, adaptive layer thickness, or functions to save material and time. Luckily, the software can be easy to [download and test before purchasing](#) a 3D printer.

One of the most significant benefits of resin 3D printing is the variety of materials that make it possible to create parts for diverse applications. Resins can feature a wide range of formulation configurations: materials can be soft or hard, heavily filled with secondary materials like glass and ceramic, or imbued with mechanical properties like high heat deflection temperature or impact resistance.

However, the range of supported material options depend on the 3D printer model, so we recommend inquiring with the manufacturer before purchase.

Parts printed with both SLA and DLP technologies require post-processing after printing. First, the parts need to be washed in a solvent to remove excess resin. Some functional materials like engineering or biocompatible parts also require post-curing. For SLA 3D printers, Formlabs offers solutions to automate these steps, saving time and effort.

At last, 3D printed parts printed on supports require these structures to be removed, a manual process that is similar for both SLA and DLP 3D printers. LFS 3D printing simplifies this step by offering light-touch support structures that use very small touchpoints to enable easy removal with minimal support marks left behind.