envisionTEC
15 YEARS BETTER

Advanced DLP

For Superior 3D Printing

Learn how pixel-shifting & grayscaling technologies harmoniously anti-alias 3D edge surfaces to allow fast DLP printing with superior accuracy & surface finish.

Fast, Accurate and Smooth — What's the Best 3D Printing Technology?

The answer isn't nearly as simple as SLA versus DLP. Understanding pixel-shifting and grayscaling technologies, which harmoniously anti-alias 3D objects, can help discerning business customers decide.

Not all forms of 3D printing are created equal—and that truth is also evident to the visible eye within individual 3D printing processes as well.

Novices to the field sometimes debate whether SLA or DLP is a superior technology for final 3D printer performance. But even within the processes of SLA (stereolithography) and DLP (digital light processing), there are significant differences in technological approach and therefore final product.

When looking for the fastest, most accurate 3D printer with the best resolution and final surface finish, it's important to dig into these details when business performance is on the line.

Why? Because post-processing is the dirty little secret of 3D printing, and nobody wants to save time and money 3D printing parts only to lose those savings after the build is complete, with extensive cleaning, sanding and polishing.

SLA vs. DLP — The Simple Analysis

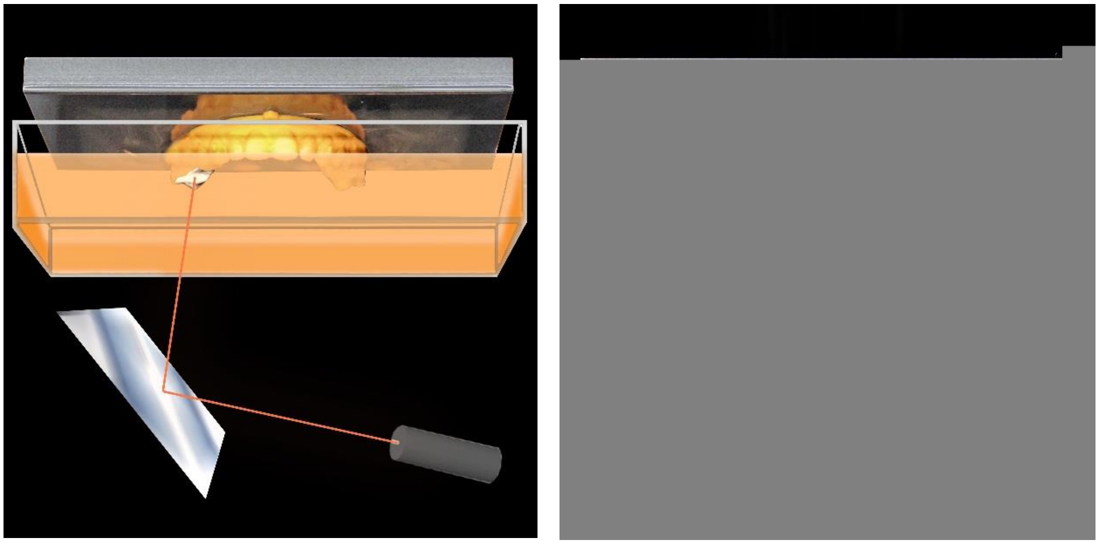
The concept for both SLA and DLP technologies is straightforward. A vat of photopolymer or resin is exposed to a light source that cures material into a final object from a digital design file.

In SLA, the light is generated by a laser. In DLP, a high-definition projector.

In an oversimplified analysis, a pros and cons list easily takes shape.

In SLA, the laser beam literally draws — lithography means "to write" — the part image onto the vat of resin, and draws in the interior, albeit not always in that order, curing the liquid, literally, line by line and layer by layer into a final part.

Surface finish is important when it comes to post-processing but accuracy is also critical. These parts are identical digital models, but the EnvisionTEC DLP delivered 96.3% part accuracy, while the SLA version was just 68.0% accurate.



SLA literally draws a part in resin with a laser light, a time-consuming process. DLP works faster because it doesn't have to draw every single line and can cure large amounts of resin in each exposure.

No matter how fast the printer goes, SLA is a time-consuming strategy. Just imagine drawing each layer individually on a sheet of paper with a fine-point pen, outlining the shape and then coloring in the dense middle sections perfectly with that same pen, page after page. While it may take more time, in the end, the process, theoretically, delivers a more tightly cured product with a finer edge.

In generic DLP, meanwhile, a high-definition projector flashes each complete layer onto the polymer, a process more akin to taking an ink stamp to each page. But because a projector delivers light in pixels — creating volumetric pixels, or voxels, in the resin — there’s an undeniable square, pixelated shape that inhibits smooth edges.

This is the quick analysis of SLA versus DLP. But is it the whole story? Not nearly — especially if you dig into the multitude of patents filed globally for these processes.

The rest of the story, as they say, is why experience truly matters when it comes to process technology in 3D printing.

Consider: What if DLP figured out a way to smooth out its pointed, pixelated edges? Would it be — could it be —better than the best SLA?

Advanced DLP solves the challenges of a generic DLP approach, and consequently, offers speed, accuracy and smooth surface finish.

Advanced DLP Offers Surface Quality and Speed

EnvisionTEC's experienced 3D printing engineers, who are pioneers in additive manufacturing, answered these questions more than a decade ago. That's why the company leads the industry in delivering highly accurate DLP parts, down to 10 microns, with a smooth surface finish that requires little to no post-processing.

Consequently, industries that demand the highest in part accuracy and smooth organic shapes, such as the hearing aid and dental industries, prefer EnvisionTEC 3D printers for mass customized production. Six out of ten hearing aids made globally today are made on EnvisionTEC printers, and dentists, orthodontists and dental labs are rapidly adopting EnvisionTEC's advanced DLP printers for the same reasons: highly accurate, smooth fuss-free surfaces.

Al Siblani, left, EnvisionTEC's founder and CEO, and Alexandr Shkolnik, EnvisionTEC's chief technology officer, led the development of two methods of smoothing out pixelated surface edges in three dimensional objects using DLP technology. Their patents on these 3D anti-aliasing techniques were filed in the early 2000s.

EnvisionTEC uses several patented and proprietary approaches to delivering these outstanding curves and smooth surface finishes.

To understand why these methods work so well, let's first identify the root of the problem with a generic DLP approach.

A projector delivers light in square-shaped pixels, which create volumetric pixels, also known as voxels, when the light cures resin.

Along a curved edge, this causes what the industry refers to as "stairstepping" – a jagged edge reminiscent of an early-era 8-bit video game.

Adding to the challenge, the size of each pixel is predetermined by an easy formula: each pixel is the size of the build space, or work envelope, divided by the resolution of the projector. The smaller the object being printed, the less of an issue a user will have with stairstepping, but the bigger an item gets, the more pronounced the pixels and stairstepping gets.

What's more, the size of the pixels cannot be changed without changing the size of the projector or the build space.

In the early 2000s, a small team of engineers in Germany and the United States led by Al Siblani, EnvisionTEC's founder, and Alexandr Shkolnik, EnvisionTEC's chief technology officer, developed two separate methods of smoothing out pixelated stairsteps.

Their first solution, quite simply, cuts the size of each stairstep by half a pixel. EnvisionTEC filed a patent for this approach (US7790093 B2) in 2005.

Enter solution No. 1: The EnvisionTEC ERM.

This is photograph of the EnvisionTEC Enhanced Resolution Module, which moves a half pixel in X and Y, to slightly shift the second exposure in its DLP machines and reduce stairstepping in a sophisticated 3D anti-aliasing technique. The projector shines through the center of the module.

EnvisionTEC's Enhanced Resolution Module, or ERM, is a physical device — manufacturing in the company's Germany facility — that deliberately causes a tiny and precise amount of "pixel shift" in the projector delivering the light. This shift literally cuts the issue of stairstepping in half, for objects that are both large and small.

This process is also why the curved surface finish from EnvisionTEC DLP printers is *at least* twice as good as its competitors, even when using the same resolution projectors. EnvisionTEC's Desktop and Perfactory DLP machines comes with HD projectors in varying resolutions, from 1400 x 1080 to 1920 x 1200.

The ERM device isn't a simple "module." Rather, it's a complete electromechanical system. A controller box delivers an electric current — one for movement in X and another for movement in Y — to a small square-shaped metal plate with a hollow interior that physically sits just below the projector. This device, when strategically excited by electricity, allow for a tiny amount of tightly controlled motion in X and Y.

The ERM literally shifts the projection a half pixel to the left or right in X or a half pixel up or down in Y.

With generic DLP technology, a 3D printer might flash a complete image layer for, say, 10 seconds as it builds an object. With EnvisionTEC's ERM pixel-shifting technique, each exposure is done twice.

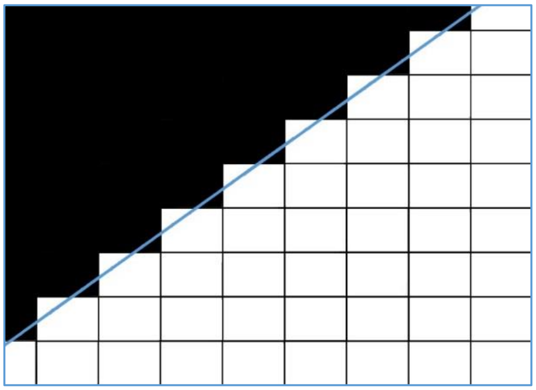
In this example, let's say the first baseline exposure is for five seconds where original curing should take place. But the next five second exposure is shifted a half-pixel left in X and down in Y, reducing any stairstepping in half.

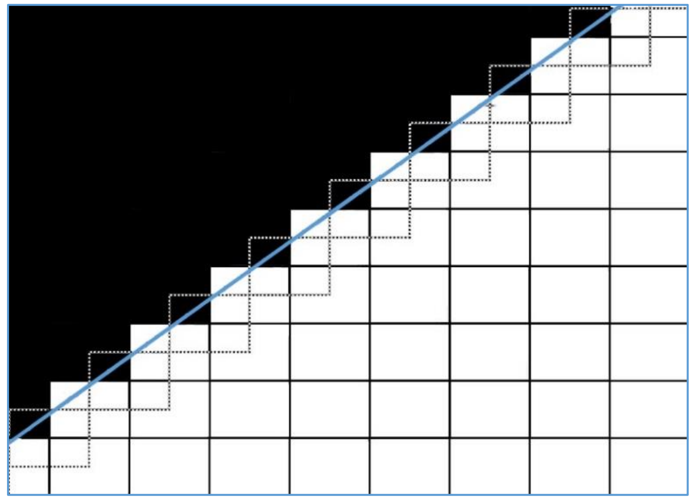
The ERM literally shifts the projection a half pixel to the left or right in X or a half pixel up or down in Y.

Depending on the size of the final object being built, this reduction of stairstepping can make stairstepping virtually undetectable to the human eye.

This pixel-shifting is completely controlled and regulated by EnvisionTEC's proprietary Perfactory software, too, so users don't need to manually control it. The system works automatically to smooth surface finish.

But EnvisionTEC didn't stop there in its quest to deliver the best surface finish.





The image above shows how regular pixelated stairstepping occurs with a generic DLP approach. But with EnvisionTEC's ERM pixel-shifting, shown to the right, the pixels are shifted to half of X and Y of the original exposure, reducing sharp stairstepping in half.

But Wait, There's More — Anti-aliasing With Grayscaling

EnvisionTEC combines its pixel-shift strategy with another patented and proprietary method called grayscaling, which is, simply put, an anti-aliasing technology for 3D objects.

The first patents for this method were filed in 2007, in both Germany and the United States. (EP1849587 B1, US20080038396A1, US20070260349A1)

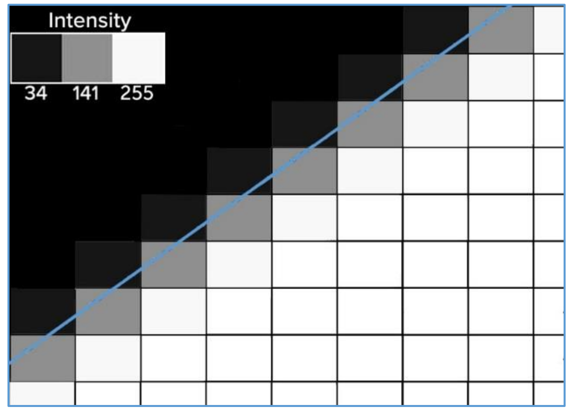
Anti-aliasing technologies are prolific today — used in 2D digital platforms virtually everywhere images appear digitally, from video games and TV screens to pretty much anything that has a digital monitor. In today's digital world, there are many high-tech methods of anti-aliasing to smooth the edges of all the pixelated images we see every day.

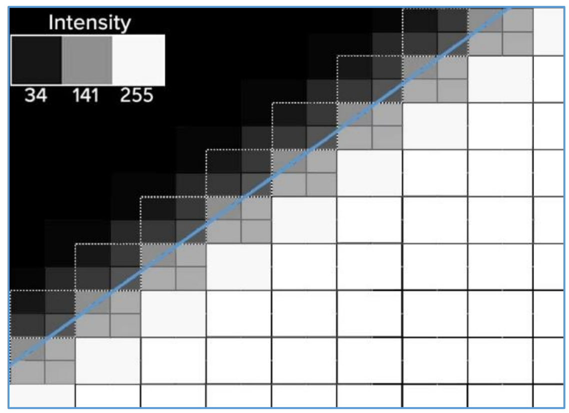
> Anti-aliasing technology, which smooths pixelated edges, is commonplace in today's digital world, but EnvisionTEC figured out a way to bring the method to 3D printing.

EnvisionTEC was the first 3D printing company to figure out a way to convert this anti-aliasing strategy to 3D voxels from a projector.

So, after EnvisionTEC's ERM technology has cut the stairsteps in half, the company's proprietary grayscaling technique smooths out whatever remains of these "jaggies," as stairstep images are known in video game circles.

Grayscaling Smooths Edges, Allows For Layer-less 3D Printing





This simplified example shows how EnvisionTEC's proprietary grayscaling technology, when combined with the company's exclusive pixel-shifting, shown below, delivers a microscopically smooth surface finish at the edge.

Unlike an SLA laser beam that is either on or off, an HD light projector can emit light in many shades, or intensities, of light along a spectrum that goes from white and gray to black.

In fact, there are 1,024 discernable shades of gray between white and black. EnvisionTEC technology uses 255 of these shades, with pure white set at 255 to dark black set at zero, to feather out edges in a sophisticated and controlled fashion.

EnvisionTEC's smart and proprietary software controls each individual pixel at the curved edge of an object, setting it in a feathered rainbow of grays, in order to deliver a smooth, anti-aliased edge.

What's more, the varying intensities made possible with grayscaling each exposure also delivers another unique effect with EnvisionTEC's DLP technology.

While the X and Y dimensions of a pixel are fixed, the Z-depth of a voxel is adjustable depending on the intensity of light delivered to each pixel through grayscaling. That means while generic forms of DLP print flat layer by flat layer, EnvisionTEC DLP prints each exposure in varying depths — a layer-less 3D printing strategy that enhances the smooth and accurate surface finish.

The harmonious interplay of EnvisionTEC's pixel-shifting ERM technology, combined with grayscaling, delivers a market-leading surface finish with no striations or stairstepping.

Beyond what's visible and can be felt, however, scans of final parts show this technology is more accurate than SLA, too.

These parts were made from the same digital file, and may look similar, but the image on the left, 3D printed with EnvisionTEC's advanced DLP technology, has a smoother surface finish and is more accurate. The EnvisionTEC-printed part is 96.3% in tolerance, while the SLA made part is 69.8% accurate.

EnvisionTEC DLP Technology Delivers Speed and Accuracy Advantages

For dentists, orthodontists and dental laboratories, who demand accuracy, smooth surface finish and production speed, the differences between SLA and EnvisionTEC's advanced DLP technology can be stark.

In a comparison test of EnvisionTEC technology versus a competitor, EnvisionTEC 3D printed three dental models in a horizontal build orientation on an EnvisionTEC Vida and a low-priced SLA machine.

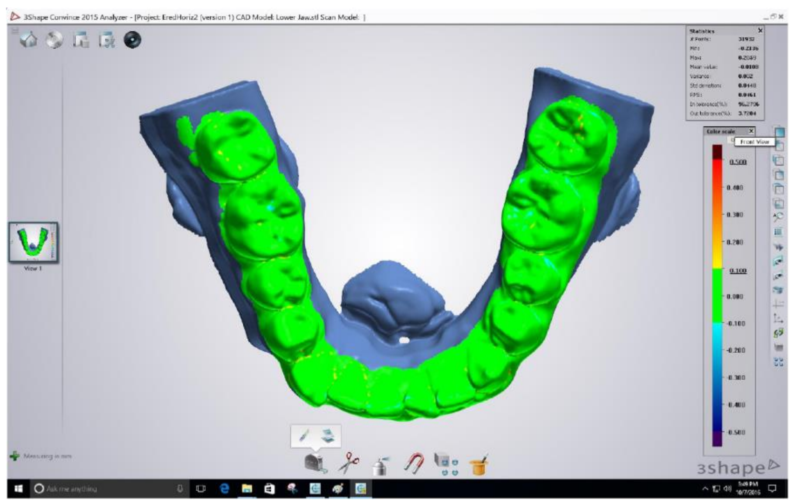
The final part accuracy of the models made on the Vida ranged from 94.7% to 96.3%, compared to the original digital model, as measured by 3Shape Software.

The comparison SLA part, meanwhile, delivered accuracy levels ranging from 68.0% to 79.1%.

Importantly, the models built on the SLA machine took almost three hours longer than the Vida.

EnvisionTEC's superior accuracy, build times and surface finish are frequently observed in routine cross-comparisons with competing 3D printers.

This dental model was 3D printed horizontally on the EnvisionTEC Vida 3D printer and has scan accuracy against the original digital model of 96.3%.



This dental model was printed on a low-priced SLA 3D printer and has scan accuracy against the original dental model of 69.8%. That means the model is out of tolerance by 30.2%.