

3D Printing 101 — Stay Flat and Parallel

In an effort to shortcut the cost of making a 3D printer, some low-cost manufacturers offer bouncy material trays that don't allow for a consistent exposure layer.

There are a variety of low-cost 3D printers on the market today that shortcut one of the most essential and basic features of a high-quality 3D print job: a fixed and flat exposure surface.

Essentially, these printers leave their customers, often first-time users of 3D printing technology, building parts on a trampoline: a flexible film that can bounce both up and down during build projects.

This cost-saving shortcut can significantly distort part accuracy and surface finish. It also increases the chances of a print failure, where the printed object doesn't stick to the build plate.



The quality of the material tray used during 3D printing can have a significant impact on the quality and accuracy of the final part, because light must travel through the bottom of the tray to cure an even layer of resin across the build platform. On the left, a used material tray from a budget 3D printer. On the right, a robust material tray from EnvisionTEC that is made with optical glass and an aluminum frame.

Ensuring a Consistent Build

It's easy to understand why flexible material trays are a challenge to quality 3D printing.

Before a print even begins, the digital object to be built is divided by a software program into flat, even slices at a preset layer thickness, usually about the thickness of a sheet of paper. At EnvisionTEC, these layers are further divided into volumetric pixels or voxels.

These digital cutaways are called Z-slices or voxel data because they are cut along the vertical Z-axis of the object in its desired print orientation.

Each Z-slice is a unique digital image that, in the common method of DLP printing, will be projected upward through a transparent material tray of photopolymer. Every exposure image will cure one thin layer of material at a time until the final object is built.

The first layer of a print job — called the burn-in layer — is actually laminated onto the flat build plate or “build platform,” which moves up in the Z axis, as the part is built upside down. Each consecutive layer is then cured onto the previously formed layer.

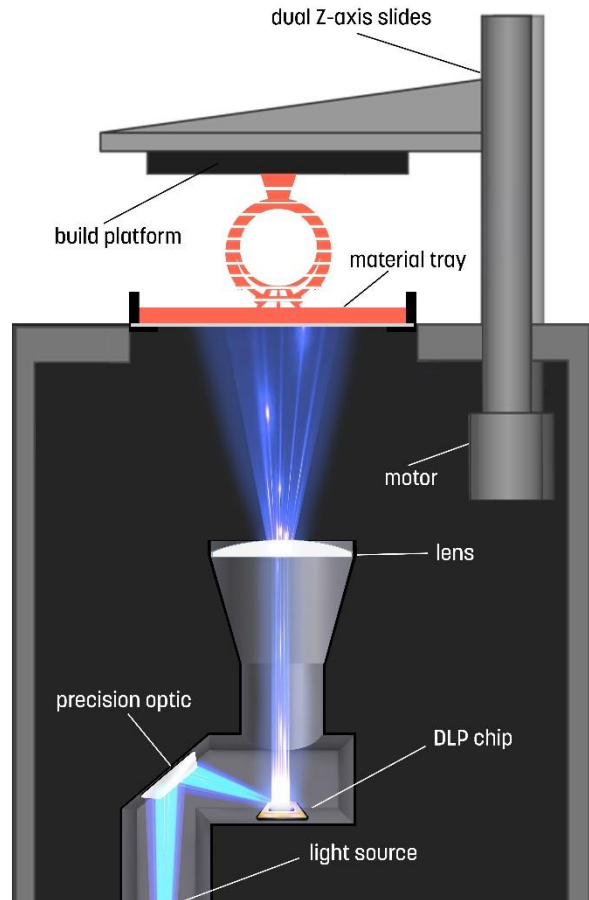
Building even small objects can take hundreds or thousands of exposures. Consider the standard chicken egg, which stands about 60 mm tall. The number of Z-slices could range from 600 for a build project where the cross-cuts are 100 μ thick, or 2,400 for a thickness of 25 μ .

To build an accurate egg, each of those paper-thin layers must be printed evenly across the entire build area again and again.

Stay Flat and Parallel for Success

To print each layer accurately, the build platform and material tray must remain perfectly *flat* and, importantly, remain *parallel* to one another from the start of the build until the end.

This is necessary because the paper-thin layer of photopolymer that is present between the build platform and material tray will be exposed and cured. If there is any unevenness between the two planes, the cross-sections won't be cured in even Z slices and accuracy will be compromised.



Sometimes, an off-balance build won't even stick to the build platform during the burn-in layer, causing a build failure.

This is also why the accuracy of the build platform's movement in the Z-axis is also so critical and why EnvisionTEC uses dual Z-axis slides to ensure parallelism, instead of one center slide, as used by many budget 3D printer manufacturers.

After the first exposure, the build plate moves up to release, or peel, the printed layer from the bottom of the material tray — 3D prints tend to be sticky — and then repositions itself downward in the material tray again for the next exposure layer.

Each repositioning of the build plate in the Z axis must be incredibly precise and parallel to the bottom of the material tray to ensure an accurate amount of material is sandwiched between the two planes. This ensures accurate curing depth.

In most DLP printers, each layer of exposure and movement of the build platform, up and down, happens in a quick sequence that is tightly controlled by software. It is a precision drumbeat of light and movement that actually exerts pressure onto the material tray.

The material tray is where all the action happens during 3D printing. The build platform moves up and down inside the material tray, in a precision drumbeat of activity as the light cures material.

Flimsy Film Trays

Yet some low-cost 3D printer companies use a flexible plastic material tray, similar to the bottom tray of a frozen dinner.

Some of these trays are movable with a light touch of the finger or concave simply by the weight of the resin they are holding.

This distortion shows how easily the bottom of the tray is to move during an active build, where the build plate is exerting and then releasing pressure on the material tray as it moves up and down in the Z axis.

This up-and-down drumbeat of build activity is also why material trays are called “consumables” and must be replaced after a certain amount of use, typically every week for low-cost trays.

The repeated positive and negative pressure of the build plate, combined with the chemical



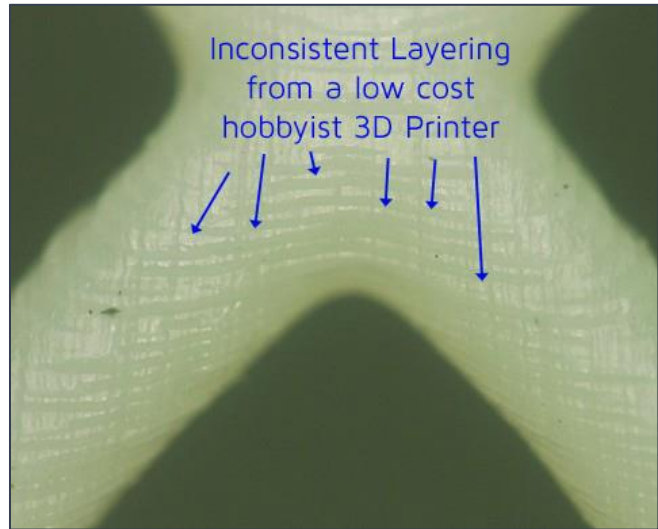
In the image above, a touch from a finger can cause flexible build trays to move, showing how prone they are to distortion during an active 3D print build.

composition of the photopolymer or resin, eventually causes the bottom area of a plastic tray to become ineffective. Over time, the tray becomes hazy, losing its transparency and the ability for light to travel through it effectively, causing sharp details to be lost and impeding accuracy.

Low-cost 3D printer companies make these trays as cheaply as possible. While that may be good for the entry price of the 3D printer, it also results in inferior 3D print jobs, [according to routine testing of competing machines by EnvisionTEC](#).

Testing showed inconsistent layer thicknesses in competitor 3D printers. In one case, where the desired layer thickness was 75 μm , EnvisionTEC documented layer thickness ranging from 64.74 μm to 141.88 μm — or errors per layer ranging from 10 to 65 microns. These inaccuracies can compound in a build, too, resulting in even greater overall inaccuracies.

Photographs of the final part also showed a nonparallel, sagging build line, consistent with a flexible material tray that is moving up and down, or not remaining flat and parallel.



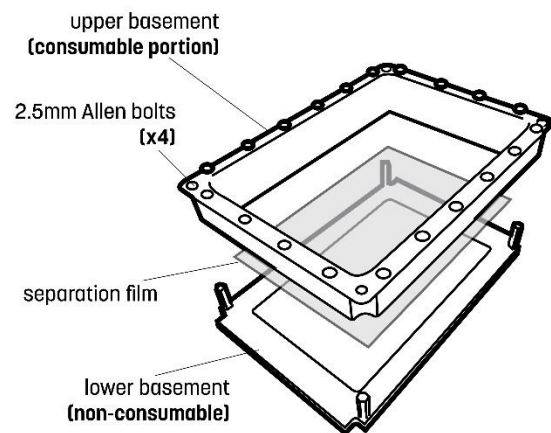
This microscopic photograph shows the result of 3D printing with a flexible build tray, which shows sagging and non-uniform part curing.

A Reliably Flat Exposure Surface

In its effort to build better 3D printers for reliable professional use, EnvisionTEC goes above and beyond to manufacture a durable precision material tray that allows for tightly controlled exposure layers on a durable and flat surface.

There are several features of the EnvisionTEC material tray that lead to consistent, reliably high-quality builds.

The first of those features is the “lower basement” of the EnvisionTEC material tray, which features industrial-strength optical glass, surrounded by a precision-machined aluminum frame made in Germany.



EnvisionTEC uses high-quality components in its material tray. Even our separation film is better, lasting up to 4 months compared to budget films that may last a week or two.

This lower basement serves two purposes. First, it acts as a fixed reference point to the upper build platform, which moves up and down in the Z axis, and ensures proper positioning. Second, it acts as a firm foundation to the upper basement and prevents the trampoline effect as the upper build plate moves up and down on the separation film, which is secured to the upper basement, during the build process. This guarantees uniform material thickness before any curing takes place.

What's more, EnvisionTEC's upper basement — a consumable product called a Pre-Stretched Assembly or PSA — is a precision manufactured assembly that features a metal encasement and a separation film that has been expertly tightened into place, similar to the way a musical drumhead is tuned, to a preset frequency.

How expertly tightened? The tension of each final PSA is actually measured by sound. Tapping the film of a PSA is similar to tapping a drumhead. The resulting sound must meet certain specifications, as measured by a digital frequency counter, before it is shipped to an end user. This guarantees a specific level of tautness of the exposure floor.

This quality PSA, combined with the rigid glass floor, ensures uniform curing in the Z-Axis.

It's just one of the many features that make EnvisionTEC's Desktop and Perfactory 3D printers better.



EnvisionTEC 3D printers offer a durable and flat exposure surface. A precision machined and assembled basement has two main components: a solid lower basement that consists of industrial optical glass that serves as a reference point to the upper build plate that moves in Z. It also features a unique Pre-Stretched Assembly or PSA, shown on top, that is expertly assembled and tightened. These are just a few of the reasons EnvisionTEC 3D printers are better.