WHITE PAPER

# Comparing SLA, DLP and PμSL

Stereolithography (SLA) was invented by Chuck Hull in the 1980's and formed the basis for founding 3D Systems, one of the leading companies in the industry. Since that time, there have been multiple variants of SLA, but all fundamentally using the process of curing a photo-sensitive material with light.

There are other additive manufacturing methods, like fused deposition modeling (FDM), selective laser sintering (SLS) and binder jet printing (BJP). They all work with the same basic premise of taking digital data and building a part layer by layer and they all have their unique advantages and disadvantages.

Photopolymerization as a category has the core advantage of allowing higher resolution and surface finish. It is why it is often the approach of choice in industries like dental, hearing aids, jewelry and other high quality applications. Historically, the negative with photopolymerization was a limitation in the range of materials available and the ability to mimic engineering grade plastics. That has begun to change in recent years as new companies have entered the market, thus bringing forward the possibilities of combining the advantages of this method (high quality) with the materials needed for end-use applications.

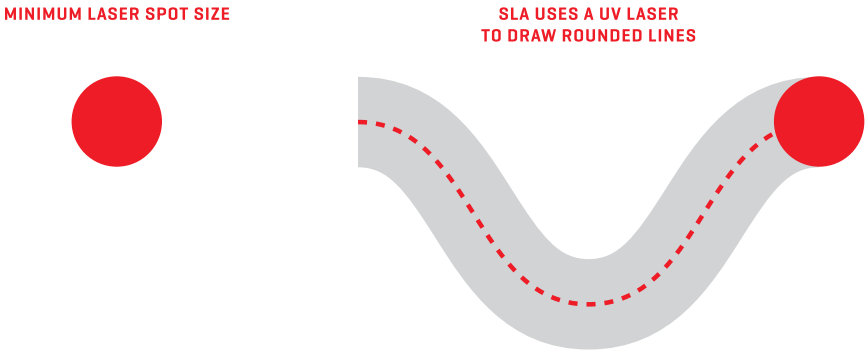
The ability to get high resolution, accuracy and precision is dependent on multiple factors. These include (1) the resolution of the optics, (2) the precision of the mechanical systems in the machine, (3) the control of the exposure and the resultant curing, (4) the interaction between the part and required support structures and (5) the overall size of the part and the ability to control tolerances across the build.

Here, we will compare laser-based SLA, Digital Light Processing (DLP) and Projection Micro Stereolithography (PμSL) and how each compare with the five factors listed above.

## Standard SLA

Standard SLA uses a UV laser to draw rounded lines, as shown below. The minimum laser spot size helps to determine the part resolution that can be obtained. The laser is directed using mirrors driven by galvanometers to aim the beam across the build print area, curing resin as it moves. The resolution and repeatability of the process can be affected by the quality and robustness of this "galvo" system. XY resolution of the printer translates to a few part characteristics that most people care about: Surface finish, edge details and crispness, minimum feature size, and part tolerance (accuracy and precision).

LASER SLA




For SLA, support structures will be required to (1) hold the part to the base (this is especially true if you are building bottom up) and (2) to support overhanging structures.

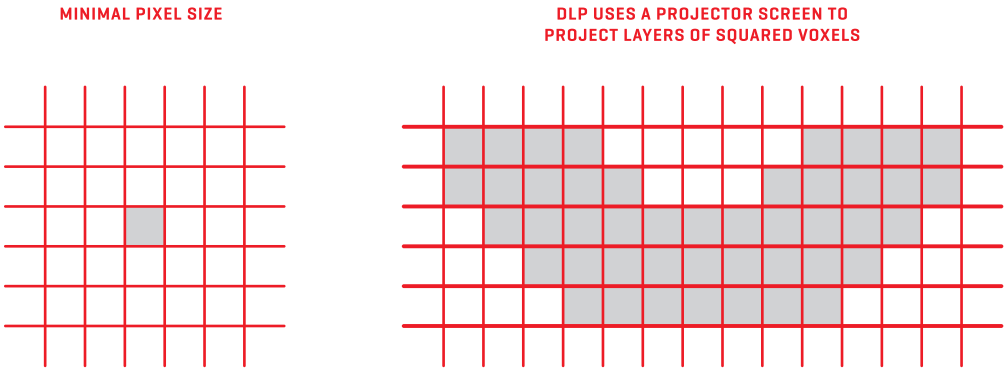
Based on all of these factors, SLA systems currently on the market can typically achieve an XY resolution of 50 µm, a minimum features size of 150 µm and overall tolerance of +/- 100 µm.

## DLP / LCD projection

DLP projection is the process whereby resin is cured by projector which flashes an image onto the resin, thus curing the entire layer at once. The resolution, accuracy and precision is achieved by the resolution of the projector (current standard is 1080P), the optical character of the projection lens and the "tightness"of the mechanical XYZ movement. Many DLP systems don't have XY movement, the image covers the entire bed. Thus, only the Z stage movement is required. To increase the printing bed size, the magnification of the projection lens increases, but comes at a cost of decreased resolution, because the DLP chip is currently limited in projection size.

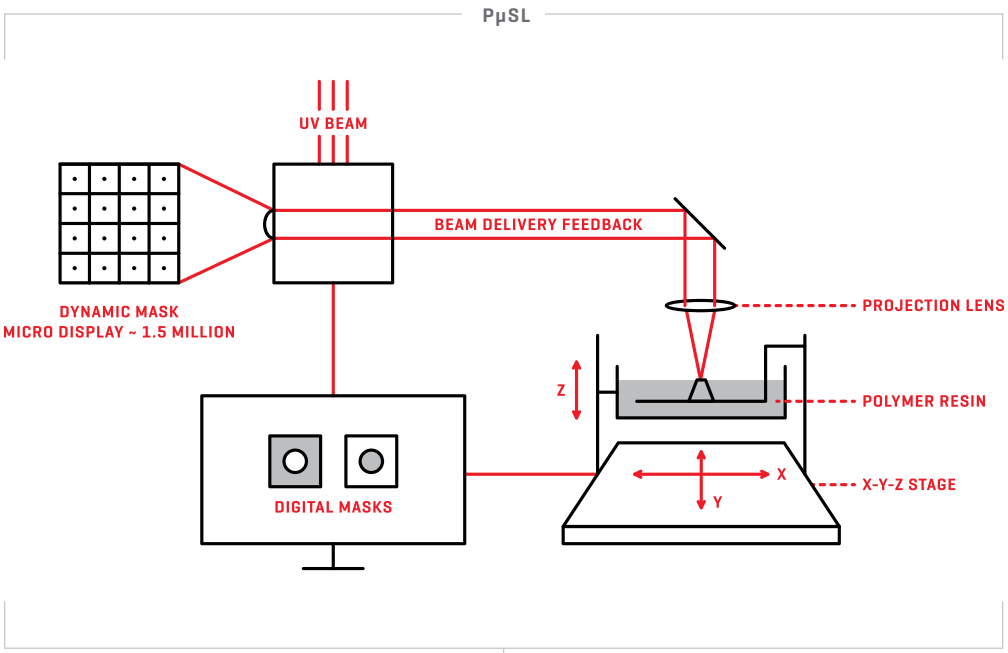
DLP systems also will require support structure for overhanging geometry and in the case of systems that use a bottom-up approach, supports are needed to secure the part to the build platform. Typically, the more supports required, the more that support-side surface finish is compromised. DLP systems currently on the market can typically achieve XY resolution of 25-50 µm, a minimum feature size of 50-100 µm and overall tolerance of +/- 75 µm.

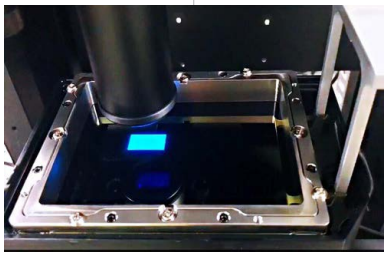
DLP



## Projection Micro Stereolithography (PμSL)

PμSL was developed as a variant to the DLP process and to increase the resolution while maintaining the ability to print larger parts (or multiple parts) at high tolerance. PμSL is accomplished by adding a few key elements. First, a high precision lens is placed between the projector and the resin batch, thus focusing the resolution to desired levels. Second, to be able to print larger parts (or multiple parts), the bed moves in the XY plane, allowing the ability to image multiple times while maintaining resolution. Finally, the PμSL process from Boston Micro Fabrication is top down. The top down scheme not only minimizes the number of support structures required, but also provides a way to reduce the damage to small features and remove bubbles with a transparent membrane. No supports are need to secure the bottom surface to the print surface and limited supports are required for overhangs due to the interaction of often light weight parts and buoyancy of the resin. PμSL systems from Boston Micro Fabrication can achieve XY resolution down to 2 μm, minimum feature size of 10 μm and dimensional tolerance as high as +/- 10 μm.



## Summary

Photopolymerization techniques bring the advantage of high part quality and an increasing range of material choice. DLP systems bring the speed required to be a viable choice for end-part production applications. PμSL has now added the resolution, accuracy and precision required for high quality parts like electrical connectors, medical devices and MEMS. As the market evolves further, hardware, software and materials innovations will continue to open up adoption for additive manufacturing in end-part production.