

# 3D Printing Technologies

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# Outline

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# Introduction

There are a number of different technologies used for 3D printing. These range from low end consumer and hobbyist units that fuse melted plastic to high end units that can make metal parts of jet and rocket engines.

There are likely new methods being developed in the lab so this presentation can only be an overview of some of the more common methods right now. The best way to find out about the latest developments is to search online.

Note that the boundaries between the technologies aren't always as cut and dried as one might expect. There are printers that straddle the boundaries or use hybrid technologies.

# Technologies

- Binder Jetting (BJ)
- Digital Light Processing (DLP) aka Direct Light Processing (DLP)
- Direct Metal Laser Sintering (DMLS)
- Drop on Demand (DOD) aka Material Jetting (MJ)
- Fused Deposition Modeling (FDM) aka Fused Filament Fabrication (FFF)
- Electron Beam Melting (EBM)
- Laminated Object Manufacturing (LOM)
- Stereolithography (SLA)
- Selective Laser Melting (SLM)
- Selective Laser Sintering (SLS)

# Binder Jetting (BJ)

Developed in 1996, Binder Jetting (BJ) uses a thin layer of powder is placed on a platform and a binding agent is selectively sprayed to join the powder particles. The platform is lowered by the layer height and a new layer of powder is deposited. The advantage of this method is that no support structure is required since the unprocessed powder provides support. Depending on the material used, post processing may be required.

# Digital Light Processing (DLP) aka Direct Light Processing (DLP)

Developed in 1987, it is similar to the earlier Stereolithography (SLA) method, except that instead of scanning each layer with a laser, it uses a system similar to a video projector to expose a whole layer at a time. Because of this, it can be faster than SLA.

## Drop on Demand (DOD) aka Material Jetting (MJ)

Think of a cross between an inkjet printer and Stereolithography (SLA). This method originated in 1994. It primarily uses a wax or photopolymer which is sprayed onto the platform. If a photopolymer is used, it is then cured by an ultraviolet light. This method is under development with new materials being developed for ceramic or metal objects. It is also used in some biological applications to deposit cells to build up 3D printed tissues. Metal or biological applications tend to be called Drop on Demand while other applications tend to be called Material Jetting.

# Fused Deposition Modeling (FDM) aka Fused Filament Fabrication (FFF)

Developed in 1988, this is the method used by most consumer and hobbyist printers. It extrudes melted plastic to build up the object layer by layer. Depending on the printer, a variety of different plastics are available for use.

The basic idea of extruding material that then fuses to previously extruded material has been extended to materials as diverse as chocolate and concrete. It is not likely that a single printer will support all these materials.



# Electron Beam Melting (EBM)

Developed in 1993, Electron Beam Melting (EBM) is similar to Selective Laser Melting (SLM) or Selective Laser Sintering (SLS), except that an electron beam is used instead of a laser. A restriction is that EBM requires the material to be conductive, which effectively restricts it to metals, while the laser methods will also work on non-conductive material.

# Laminated Object Manufacturing (LOM)

Developed in the late 1980s (the first commercial printer shipped in 1991), Laminated Object Manufacturing uses a sheet of material that is positioned over the printing platform. The sheet is then cut to produce a layer of the print. Finally a heated roller is used to bind the new layer to the rest of the print. Since only the outline of a layer needs to be cut, large filled in areas can be printed rapidly.

# Stereolithography (SLA)

This is apparently the first 3D printing method developed. Developed in 1981, it uses a liquid photopolymer that hardens when exposed to light. The light is provided by a laser that scans each layer. Some processing may be required after printing.

# Selective Laser Melting (SLM) aka Direct Metal Laser Sintering (DMLS)

Developed in 1995, this method is similar to Selective Laser Sintering (SLS), except in this case the material is fully melted instead of just being sintered. A thin layer of powder is placed on a platform and is scanned by a high powered laser to form a layer of the object. The platform is lowered by the layer height and a new layer of powder is deposited. An advantage of this method is that the finished product can be made of metals that are fully fused.

# Selective Laser Sintering (SLS)

This method has a similarity with Stereolithography (SLA), except that a powder is used instead of a liquid. A thin layer of powder is placed on a platform and is scanned by a laser to sinter the powder grains together to form a layer of the object. The platform is lowered by the layer height and a new layer of powder is deposited. The advantage of this method is that no support structure is required since the unprocessed powder provides support.

# Selecting a Printer Technology

With the bewildering array of technologies available, selecting the proper printer can be a daunting task. There are ways to narrow the selection down. The first and most important thing to do is to figure out what you want to do with your printer. Some considerations are:

**Material** What materials do you want to print? This is probably the quickest way to eliminate certain technologies. If you want production quality metal parts, that will eliminate many options. If you want just want a cheap object to test form and fit, that will drive selection in a different direction.

**Budget** Costs range from a few hundred dollars for cheap FDM printers up to “the sky is the limit”. There will be some overlap between technologies as well.

**Speed** If print speed is the most critical factor, you probably need DLP or LOM printing. Again, there is overlap between many of the technologies.

**Quality** This can mean a number of different things – accuracy, detail, surface finish (before or after post processing)

# References

For more information, please refer to the references below.

- <https://www.google.com/search?q=3d+printing+technologies>
- <http://3dprintingfromscratch.com/common/types-of-3d-printers-or-3d-printing-technologies-overview/>
- <https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/>