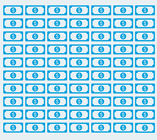
A COMPREHENSIVE GUIDE TO 3D PRINTING

3D printing is the method of joining materials, layer upon layer, to make parts from 3D model data.

Benefits [1]

- Design freedom
- Quick lead times
- Cost-effective process
- Easy customization
- Simplified workflow



$7.3 billion

Total annual revenue from additive manufacturing in 2017 [2]

= $10 million

90%

Percentage of companies that use 3D printing and consider it a competitive advantage [3]

TYPES OF 3D PRINTING TECHNOLOGIES

There are four primary 3D printing processes that have made significant impacts on the 3D printing industry. Each process uses different materials and produces results suited for various applications.

Vat Photopolymerization

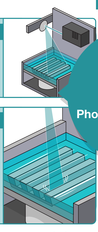
First commercialized in 1987

Notable technology

Stereolithography (SL, SLA), commercialized in **1987**

What it is

An additive manufacturing process in which liquid photopolymer in a vat is selectively cured by light-activated polymerization

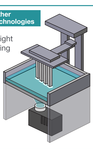


The process

A precise UV laser cures and solidifies thin layers of photo-reactive resin.

Other technologies

Digital Light Processing (DLP)



Materials

- Liquid photopolymer
- Polyurethane

Ideal applications

- Investment casting patterns
- Prototypes
- Concept models
- Master patterns

Material Extrusion

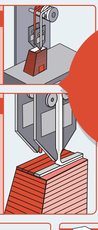
First commercialized in 1991

Notable technology

Fused Deposition Modeling (FDM), commercialized in **1991**

What it is

An additive manufacturing process in which material is selectively dispensed through a nozzle

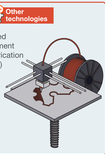


The process

Material extrusion machines force thermoplastic material through a nozzle or print head layer by layer in the XY plane. After a layer is completed, the build platform moves down, and the next layer is extruded and adhered to the previous layer.

Other technologies

Fused Filament Fabrication (FFF)



Materials

- Thermoplastics
- Composites

Ideal applications

- Production parts
- Manufacturing tooling
- Functional prototypes
- Aircraft interiors

Powder Bed Fusion

First commercialized in 1992

Notable technology

Laser Sintering (LS, SLS), commercialized in **1992** and Direct Metal Laser Sintering (DMLS), commercialized in **2003**

What it is

An additive manufacturing process in which thermal energy selectively fuses regions of a powder bed

The process

The thermal energy melts the powder materials, which then changes as it cools. For polymers, the unused powder surrounding a part serves to hold it in place, so no additional supports are needed. For metal parts, supports are required to anchor the parts to a build plate and support down-facing surfaces.

Other technologies

- Multi Jet Fusion (MJF)
- Electron Beam Melting (EBM)
- Selective Laser Melting (SLM)

Materials

- Metal powder
- Thermoplastic powder

Ideal applications

- Rapid prototyping
- Functional prototyping
- Production parts

Material Jetting

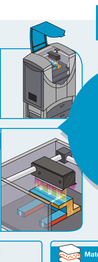
First commercialized in 2005

Notable technology

PolyJet, commercialized in **2005**

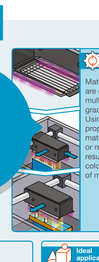
What it is

An additive manufacturing process in which droplets of material are selectively deposited.



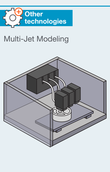
The process

Material jetting systems are capable of printing multi-material and graded material parts. Using different proportions of each material produces parts, or regions of parts, resulting in a variety of colors and a wide range of material properties.



Other technologies

Multi-Jet Modeling



Materials

- Photopolymers (cured by UV light)
- Digital materials (multiple photopolymers mixed and jetted simultaneously)
- Wax

Ideal applications

- Rapid prototyping
- Concept models
- Investment casting patterns
- Medical models

ADDITIONAL SOURCES

1. https://www.iso.org | 2. Wohler's Report 2018 | 3. https://www.forbes.com