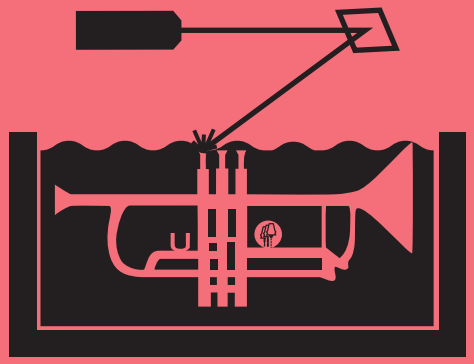
7 Families of Additive Manufacturing

According to ASTM F2792 Standards



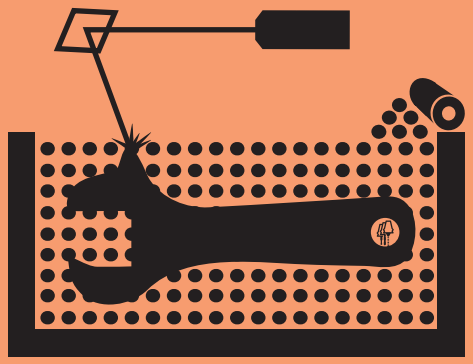
VAT Photopolymerization

Alternative Names:
SLA™ - Stereolithography Apparatus
DLP™ - Digital Light Processing
3SP™ - Scan, Spin, and Selectively Photocure
CLIP™ – Continuous Liquid Interface Production

Description:
A vat of liquid photopolymer resin is cured through selective exposure to light (via a laser or projector) which then initiates polymerization and converts the exposed areas to a solid part.

Strengths:
- High level of accuracy and complexity
- Smooth surface finish
- Accommodates large build areas

Typical Materials
UV-Curable Photopolymer Resins



Powder Bed Fusion (PBF)

Alternative Names:
SLS™ - Selective Laser Sintering; DMLS™ - Direct Metal Laser Sintering; SLM™ - Selective Laser Melting: EBM™ - Electron Beam Melting; SHS™ - Selective Heat Sintering; MJF™ - Multi-Jet Fusion

Description:
Powdered materials is selectively consolidated by melting it together using a heat source such as a laser or electron beam. The powder surrounding the consolidated part acts assupport material for overhanging features.

Strengths:
- High level of complexity
- Powder acts as support material
- Wide range of materials

Typical Materials
Plastics, Metal and Ceramic Powders, and Sand

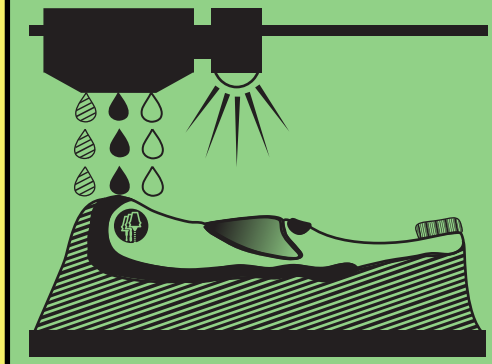
Binder Jetting

Alternative Names:
3DP™ - 3D Printing
ExOne
Voxeljet

Description:
Liquid bonding agents are selectively applied onto thin layers of powdered material to build up parts layer by layer. The binders include organic and inorganic materials. Metal or ceramic powdered parts are typically fired in a furnace after they are printed.

Strengths:
- Allows for full color printing
- High productivity
- Uses a wide range of materials

Typical Materials
Powdered Plastic, Metal, Ceramics, Glass, and Sand.



Material Jetting

Alternative Names:
Polyjet™
SCP™ - Smooth Curvatures Printing
MJM - Multi-Jet Modeling
Projet™

Description:
Droplets of material are deposited layer by layer to make parts. Common varieties include jetting a photcurable resin and curing it with UV light, as well as jetting thermally molten materials that then solidify in ambient temperatures.

Strengths:
- High level of accuracy
- Allows for full color parts
- Enables multiple materials in a single part

Typical Materials
Photopolymers, Polymers, Waxes

Created and designed by Hybrid Manufacturing Technologies. For more information go to www.hybridmanutech.com

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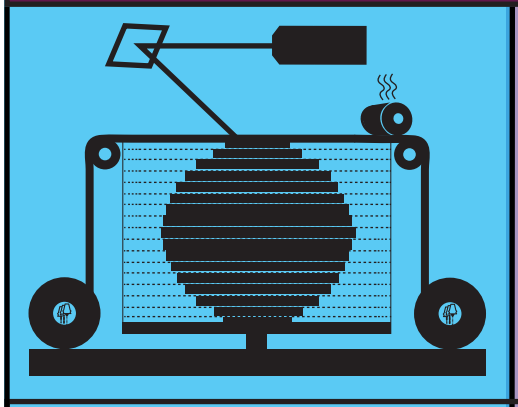


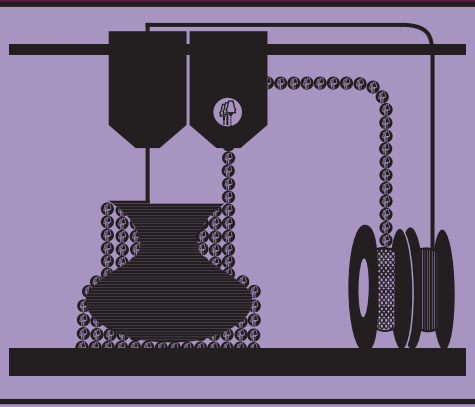
Sheet Lamination

Alternative Names:
LOM - Laminated Object Manufacture
SDL - Selective Deposition Lamination
UAM - Ultrasonic Additive Manufacturing

Description:
Sheets of material are stacked and laminated together to form an object. The lamination method can be adhesives or chemical (paper/plastics), ultrasonic welding, or brazing (metals). Unneeded regions are cut out layer by layer and removed after the object is built.

Strengths:
- High volumetric build rates
- Relatively low cost (non-metals)
- Allows for combinations of metal foils, including embedding components.

Typical Materials
Paper, Plastic Sheets, and Metal Foils/Tapes



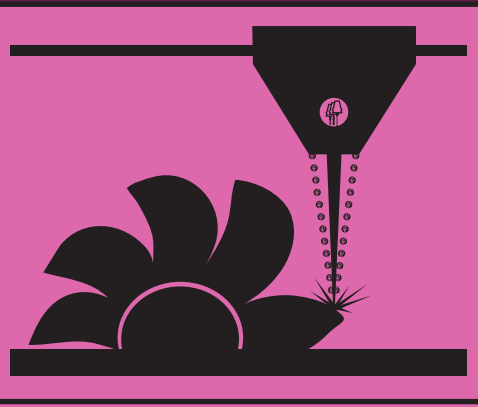
Material Extrusion

Alternative Names:
FFF - Fused Filament Fabrication
FDM™ - Fused Deposition Modeling

Description:
Material is extruded through a nozzle or orifice in tracks or beads, which are then combined into multi-layer models. Common varieties include heated thermoplastic extrusion (similar to a hot glue gun) and syringe dispensing.

Strengths:
- Inexpensive and economical
- Allows for multiple colors
- Can be used in an office environment
- Parts have good structural properties

Typical Materials
Thermoplastic Filaments and Pellets (FFF); Liquids, and Slurries (Syringe Types)



Directed Energy Deposition (DED)

Alternative Names:
LMD - Laser Metal Deposition
LENS™ - Laser Engineered Net Shaping
DMD™ - Direct Metal Deposition (DM3D)
LENS™ – Laser Engineered Net Shaping
DMD™ – Direct Metal Deposition DM3D,

Description:
Powder or wire is fed into a melt pool which has been generated on the surface of the part where it adheres to the underlying part or layers by using an energy source such as a laser or electron beam.This is essentially a form of automated build-up welding.

Strengths:
- Not limited by direction or axis
- Effective for repairs and adding features
- Multiple materials in a single part
- Highest single-point deposition rates

Typical Materials
Metal Wire and Powder, with Ceramics

HYBRID

Alternative Names:
AMBIT™ - Created by Hybrid Manufacturing Technologies

Description:
Laser metal deposition (a form of DED) is combined with CNC machining, which allows additive manufacturing and 'subtractive' machining to be performed in a single machine so that parts can utilize the strengths of both processes.

Strengths:
- Smooth surface finish AND High Productivity
- Geometrical and material freedoms of DED
- Automated in-process support removal, finishing, and inspection

Typical Materials
Metal Powder and Wire, with Ceramics