Fused Deposition Modeling (FDM)

Developed in the late 80s.

**Process Principle**

Filament is made of thermoplastic materials (*Acrylonitrile butadiene styrene* (ABS), *Polylactide* (PLA), other new materials).

Dual extruder machines exist; Temporary support structures can be made from water-soluble material, two colors.
Commercial Systems

• **Stratasys**
  – Dimension family
  • Z resolution: 0.18 mm
  • Build size: 8 x 8 x 12 inches
  • Limited color
  • Limited material types

• **MakerBot**
  • Delta 3D Printer
  • Ultimaker

https://www.youtube.com/watch?v=ik39_sv-wgQ
• Cube from 3D Systems
• And many others
Stereolithography (SLA)

Process Principle

- SLA uses liquid photo-reactive resin
- Laser beam traces one layer on the surface of the resin
- Laser light cures and solidifies parts it hits
- The platform descends by one layer
- Support structure
  - thin support lattice can be broken off
History

- Developed in the 80s, founded 3D Systems in 1986.

Commercial

• Two main families
  – ProJet
  – iPro

• Build volume: varies, can be very large

• Resolution up to 0.05mm

• Materials (only one can be used):
  – photopolymers
  – clear, opaque, temperature resistant, ceramic-like, abs-like
• Formlabs
  – Smaller build volume
  – Similar resolution
  – Much less expensive
Selective Laser Sintering (SLS)/Direct Metal Laser Sintering (DMLS)

Principle

• SLS and DMLS use a bed of small particles (made of plastic, metal, ceramic, or glass)
• High-power laser traces one layer on the surface of the powder bed fusing the particles
• The platform descends by one layer and more material is added

Features

• Laser and scanner system (similar do SLA but laser is more powerful)
• Bulk material can be preheated (reduces the required energy to melt it)
• Materials (One material at a time, glass, polymers (e.g., nylon, polysterine), metals (e.g., steel, titanium, alloys), ceramic)
• Does not require support structure (overhangs are supported by powder material)
**Single- and Two-Component Powders**

A – single-component metal powder  
B – two-component metal/metal powder mixture  
C – two-component metal/metal coated powder

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Raw Ni-alloy-Cu powder mixture  
(Tolochko et al. 2003)  

Raw Fe-Cu powder mixture

Fe powder after sintering
Fe-Cu powder mixture after sintering

https://www.youtube.com/watch?v=BZLGLzyMKn4

Commercial Systems

• 3D Systems (sPro family & Pro DM)
• EOS GmbH (Formiga and EOSINT family)
• Requires powerful laser (30W for SLS, 400W for DMLS)
• Layer thickness: 0.02 – 0.08 mm
Sample Fabricated Parts

3D printed, titanium central wing spar

Airbus wing bracket