Rapid Prototyping 101: A Primer on Additive Manufacturing Techniques and Procedures

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Class summary

- Additive manufacturing, commonly known as rapid prototyping, is becoming an extremely fast-growing manufacturing process, enabling the quick manufacture of complex parts at minimal cost. However, there appears to be a great deal of confusion and misinformation regarding process capabilities and uses. In this class we will help you to understand the information surrounding this significant manufacturing process. You will gain an understanding of the current 3D printing techniques, the capabilities and limitations of the technology, and the brief history of rapid prototyping.

Key learning objectives

Learning Objectives:

- Gain a base-level understanding of current 3D printing techniques
- Gain a general understanding of the history of 3D printing
- Understand the capabilities of 3D printing
- Understand the limitations of 3D printing

Outline of Presentation

- Additive vs. Subtractive
  - Stereolithography
  - Granular-Based Techniques
  - Laminated Object Manufacturing
  - Filament Extrusion

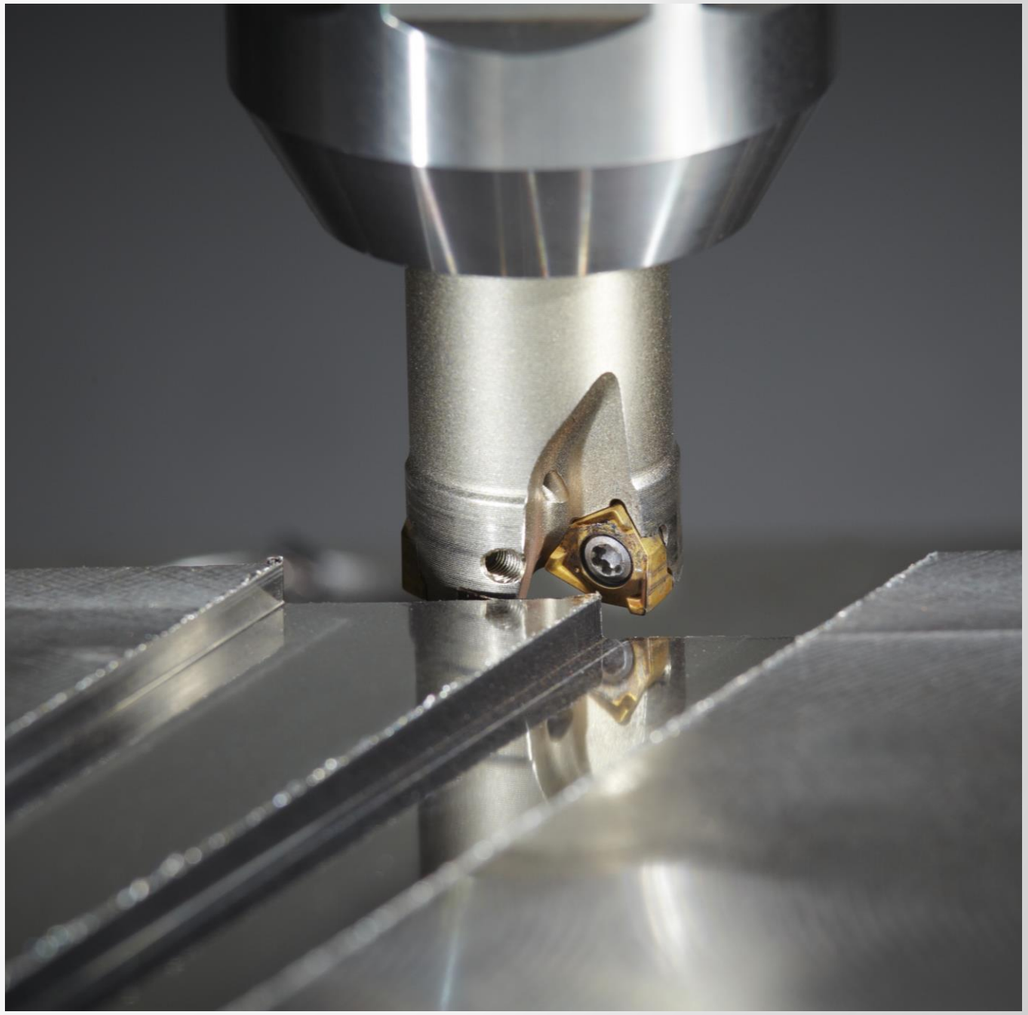
What is Rapid Prototyping?

What is Rapid Prototyping?

- The process of quickly creating a prototype from 3-dimensional CAD data, using a wide variety of techniques.
  - (Yes, this is very vague. But don't worry, we will get through this)
- Subtractive vs. Additive

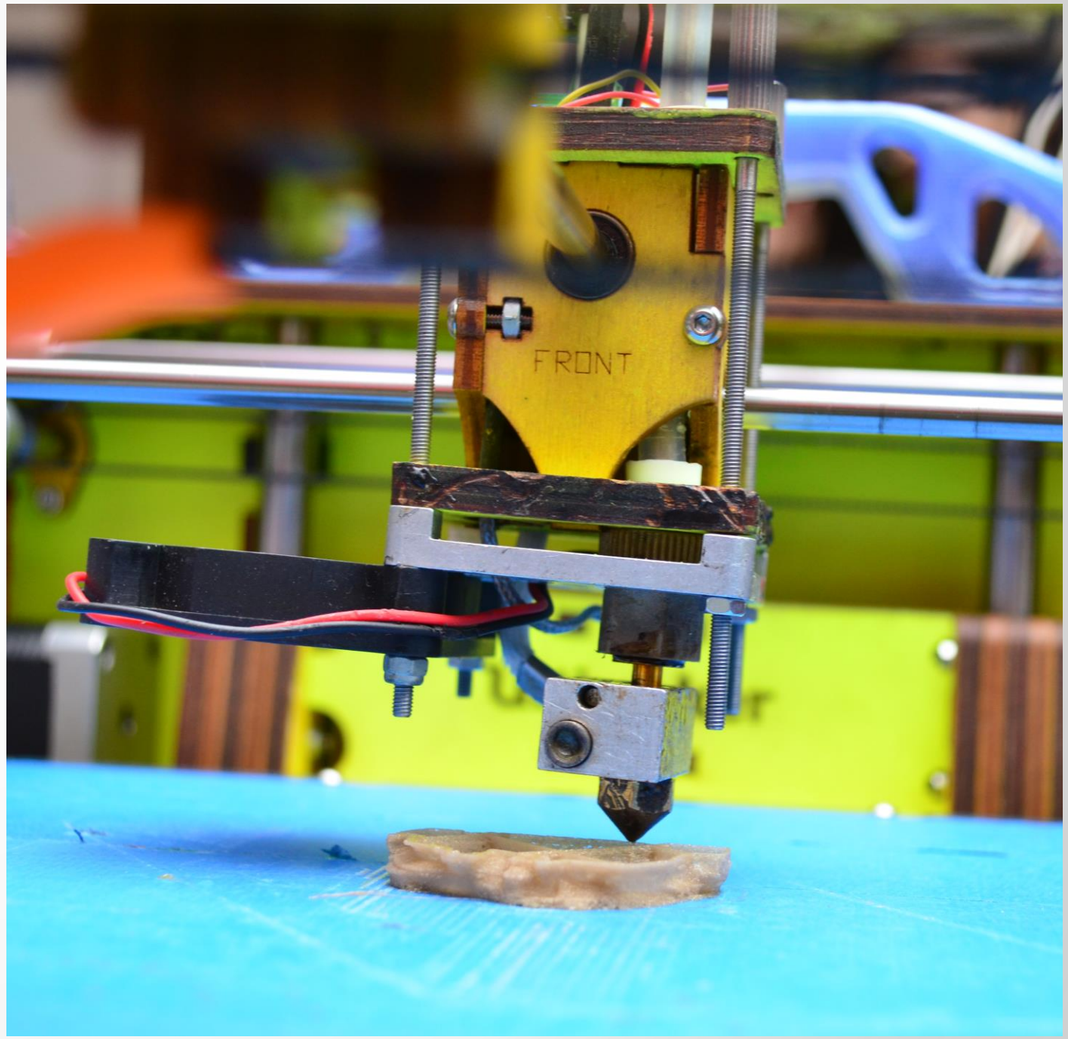
Additive Manufacturing vs. Subtractive Manufacturing

- Subtractive Manufacturing
  - Prototyping was Traditionally Subtractive Process
  - Material is removed to create a part (think CNC machining)
  - Expensive process
  - Limited Design complexity



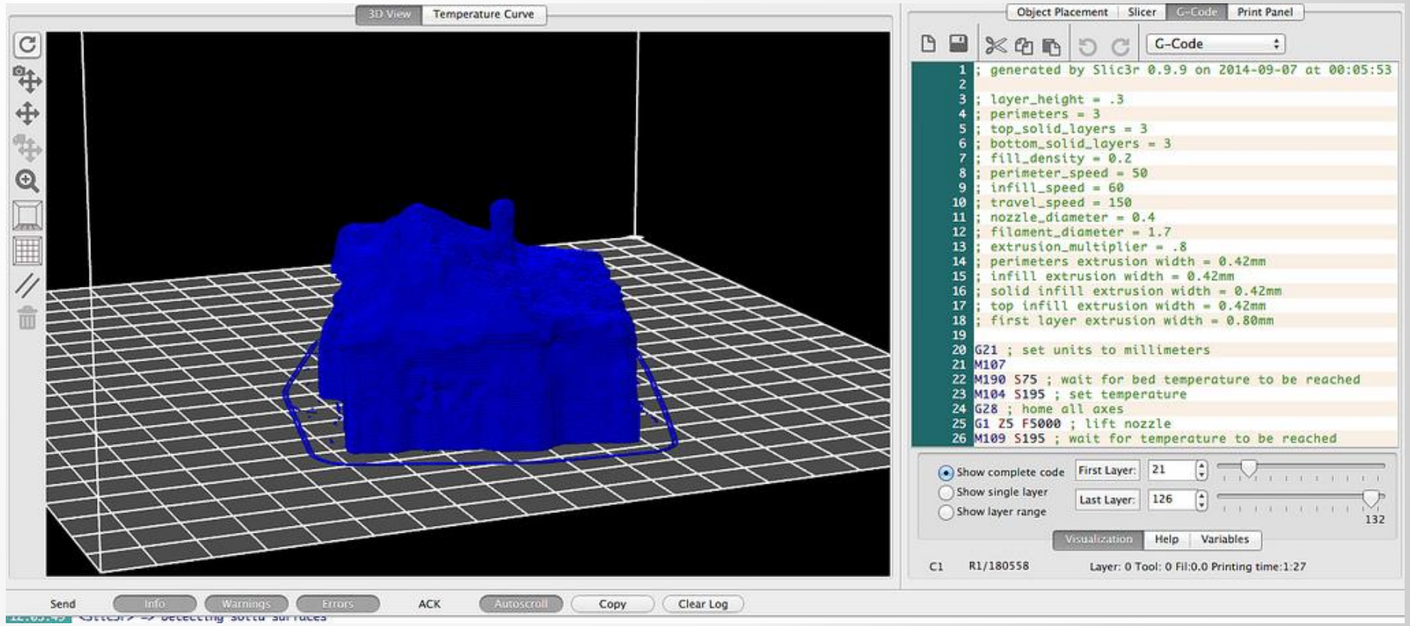
Additive Manufacturing vs. Subtractive Manufacturing

- Additive Manufacturing
  - The process of manufacturing a part by laying down a series of successive layers.
  - Developed in the early 1980s, commercialized later that decade
  - Commonly referred to as 3D Printing



Additive Manufacturing vs. Subtractive Manufacturing

- Starts with a CAD model
- Model run through a “slicer” software
  - Converts into layers
  - Generates g-code
- G-Code loaded into machine
- Machine Prints Part



Stereolithography (SLA)

How does it work?

- Uses Ultraviolet (UV) curable “photopolymers”
- Traditionally used a bath of material

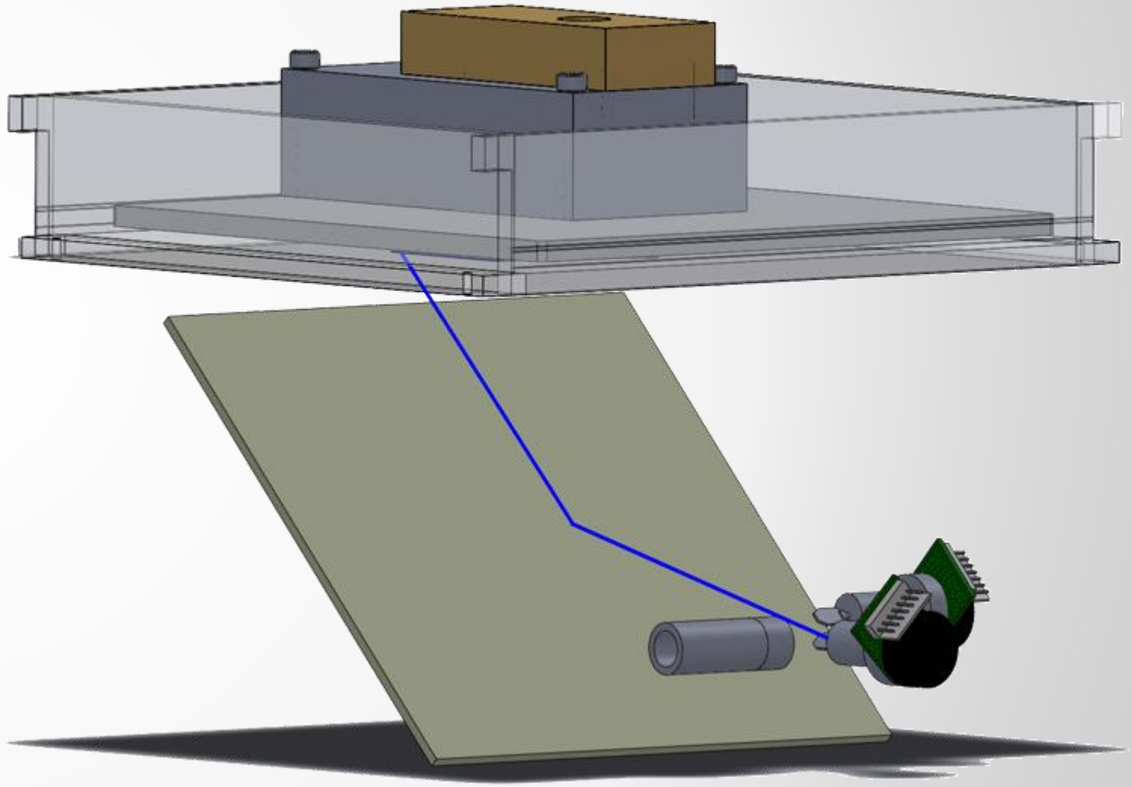


Image from http://www.fsl3d.com/

History

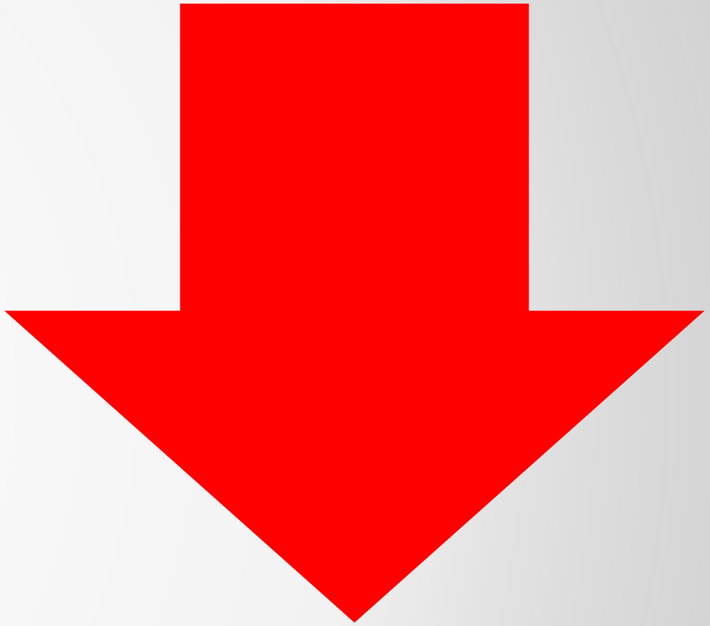
- First Commercialized form of Rapid Prototyping
- Process invented by Charles W. Hull
- Commercialized technology based on Hull’s patent, published in 1986
- .stl (or STereoLithography) file format

Advantages

+ Fast
+ Widely Available
+ Huge library of available materials and material blends
  + (Material and color blending exclusive to polyjet)
+ Very accurate

Disadvantages

- Price
- Requires Support Structure

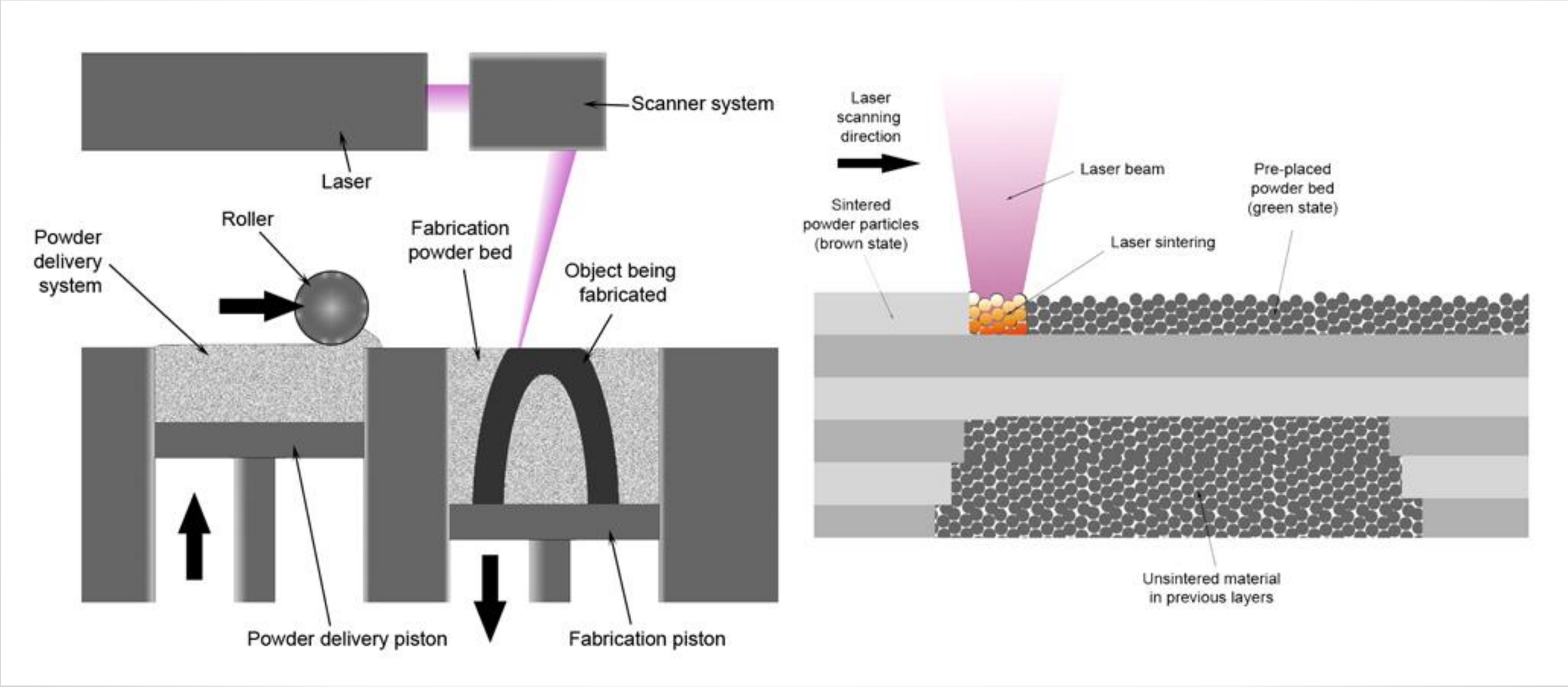


Granular-Based Techniques

How does it work?

- Uses a powered material
- Material is joined in a 2D cross-section
- More material is brushed over top
- Process is repeated
  until a part is completed

Selective Laser Sintering-SLS



History

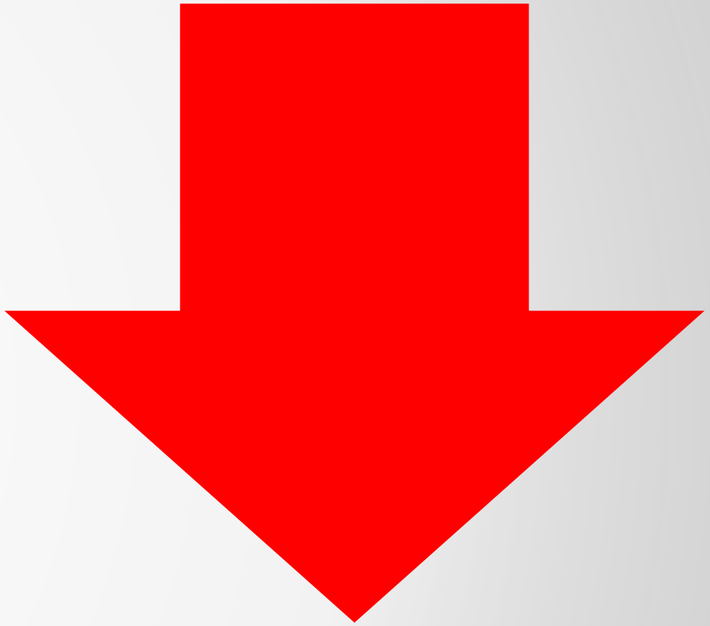
- Developed and Patented in the mid 1980s by Dr. Carl Deckard and Dr. Joseph Beaman
- Deckard and Beamen established DTM Corporation
- In 2001 DTM was purchased by 3D Systems

Advantages

+ Fast
+ Many Materials
+ Accurate (less than SLA)
+ No support structure required
+ High production volumes

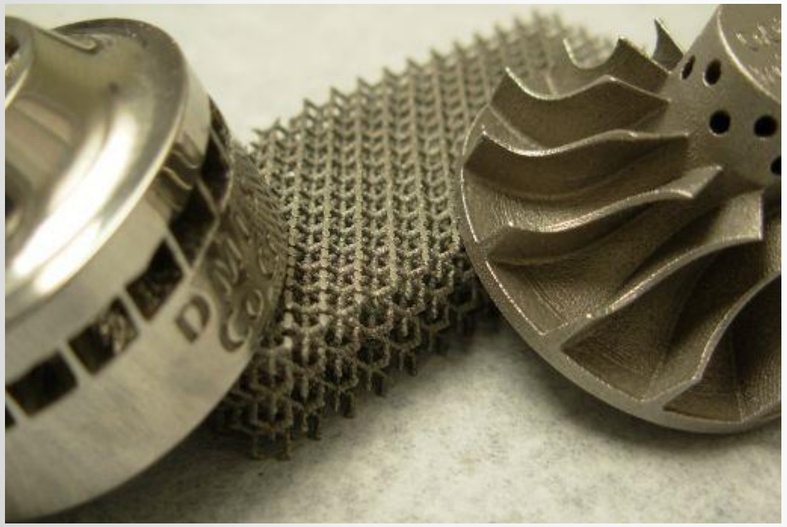
Disadvantages

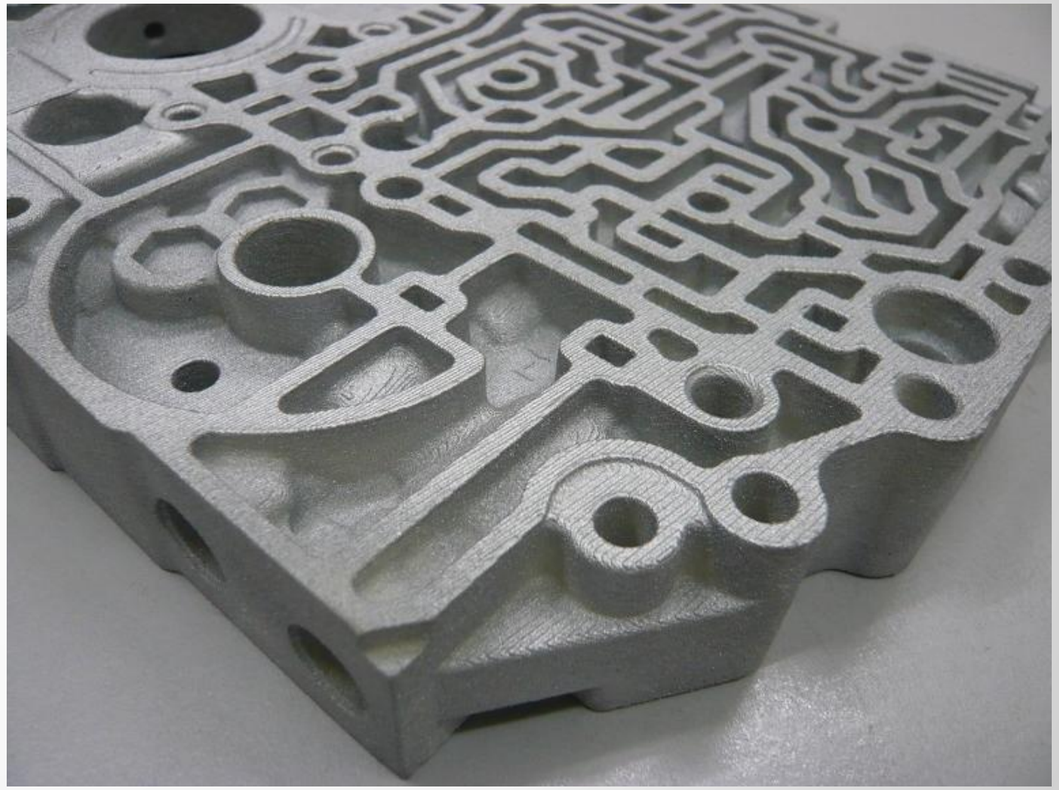
- Expensive Machines
- Messy
- One material per part
- Part Density



Other Techniques

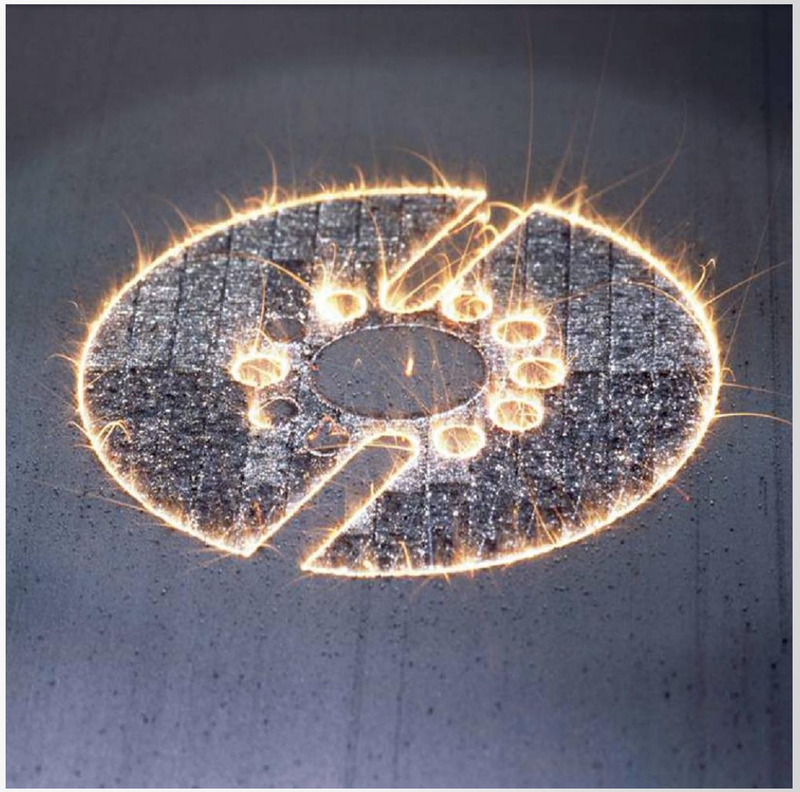
- Direct Metal Laser Sintering (DMLS)
  - Uses a fine powdered metal





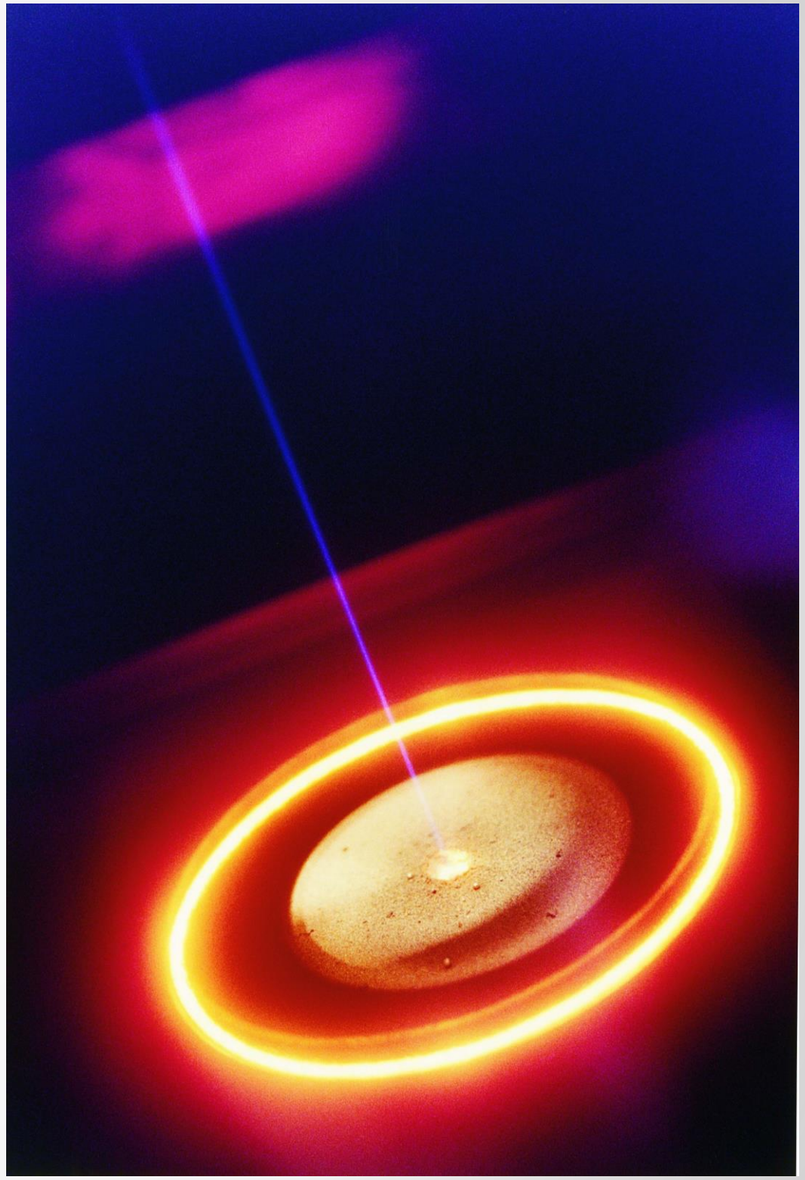
Other Techniques

- Selective Laser Melting (SLM)
  - Material is fully melted rather than sintered



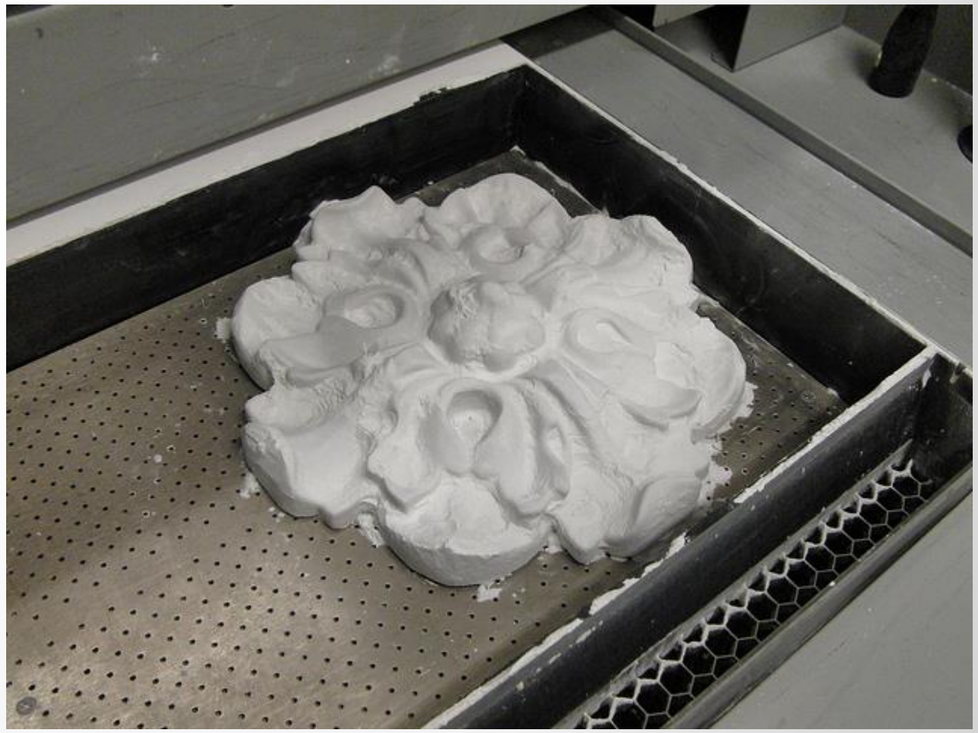
Other Techniques

- Electron Beam Melting (EBM)
  - Material melted via electron beam in high vacuum



Other Techniques

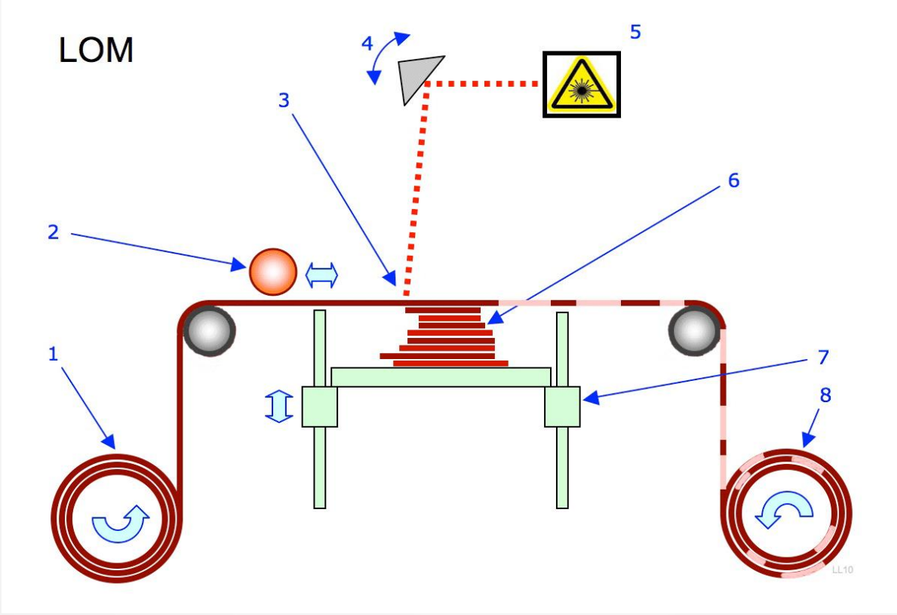
- Powdered Bed & Inkjet 3D Printing (3DP)
  - Powdered material joined with a binding agent



Laminated Object Manufacturing

How Does it Work?

- Laminated Object Manufacturing (LOM)
  - Layers of material (usually paper or plastic) are joined with an adhesive, while a knife or laser cuts cross sections of part

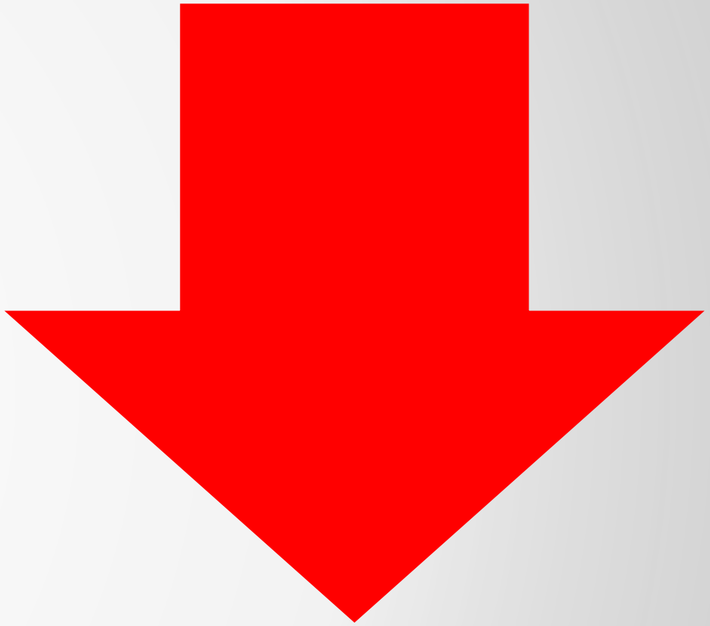


Advantages

+ Inexpensive Materials
+ Affordable Printers
+ No support structure needed
+ Full color models

Disadvantages

- Accuracy
- Waste Material
- Parts must be coated
- Less Common

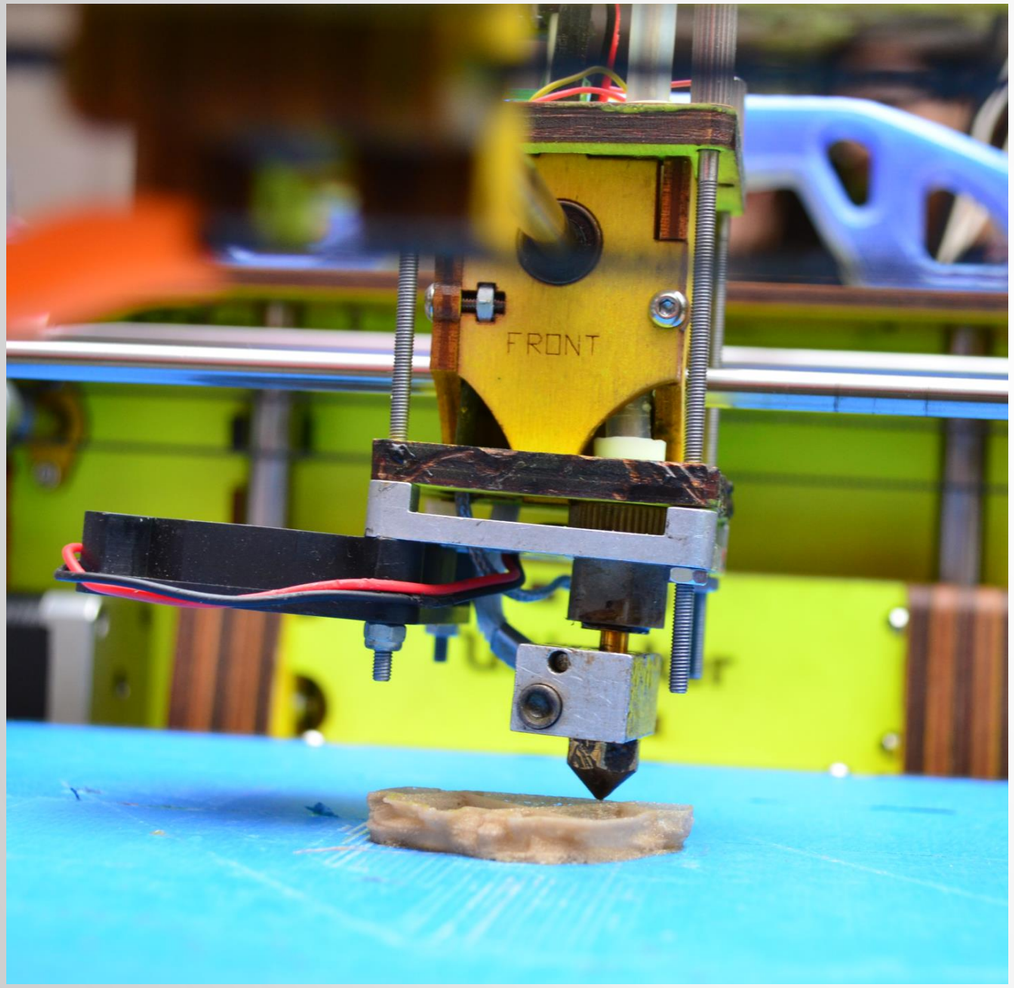


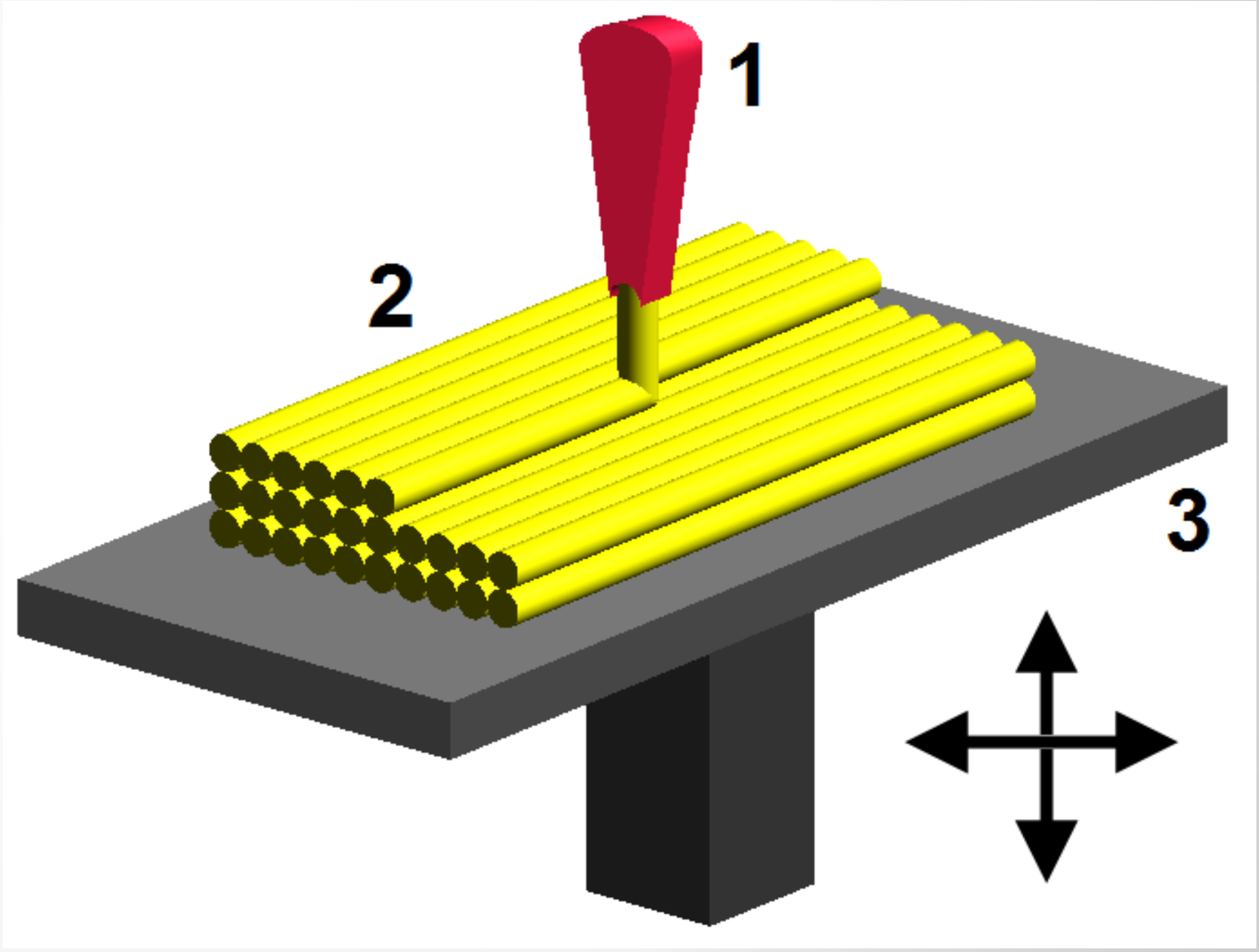
Filament Extrusion

How does it work?

- Relies on a filament of material
- Filament is extruded through heating element along 2D cross section
- Process is repeated over the top of previous layer until part is produced.

Fused Deposition Modeling-FDM
Fused Filament Fabrication-FFF





History

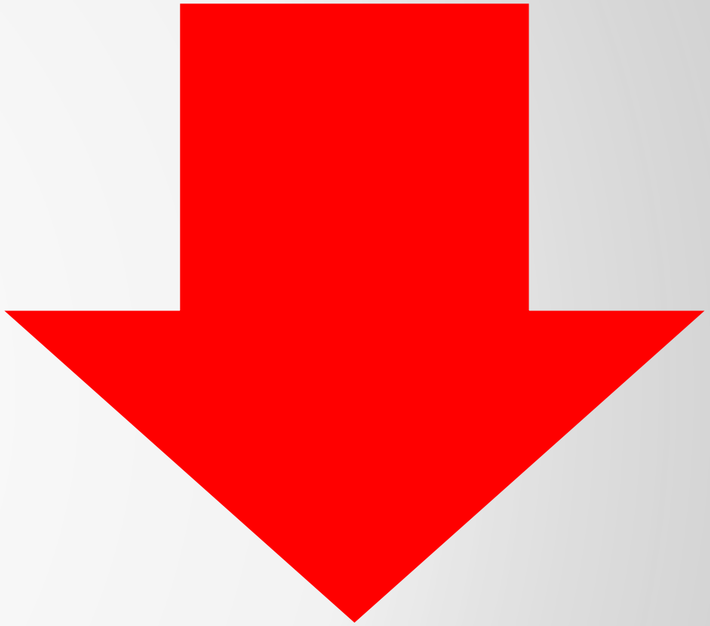
- Developed by S. Scott Crump in late 1980s.
- Crump patented FDM process in 1989.
- Patent expired in early 2000s, spurring maker movement
- Often referred to as FFF, as Stratasys has trademarked FDM

Advantages

+ Cheap
+ Widely available
+ Material Diversity
+ Part weight
+ Multiple materials in one part

Disadvantages

- Non isotropic part properties
- Dimensional accuracy
- Requires supports
- Material Curling



Other Techniques

- Electron Beam Freeform Fabrication (EBF^3)

Questions?

Session Feedback

- Via the Survey Stations, email or mobile device
- AU 2014 passes given out each day!
- Best to do it right after the session
- Instructors see results in real-time