3D Printing Technology

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- SLS, Selective laser sintering

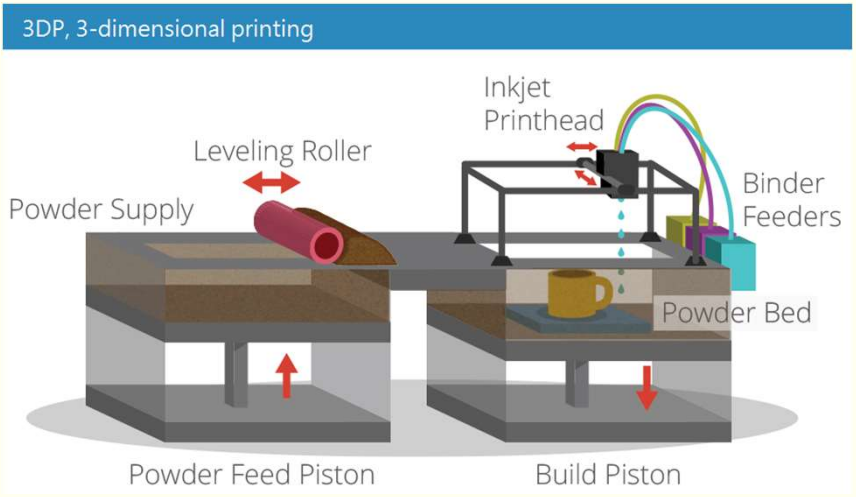
3D Printing Technology

- Additive process
- 3-D digital data -> 2-D slicing
- Layer by layer build-up
- Low volume manufacturing
- Rapid prototyping
  - Intermediate step
  - Design support or verification
  - Plastic mold part, cast mold pattern or "mock-up" part
- Rapid manufacturing/production
  - Near net shaped product or prototype (accuracy and finish)
  - Functional part (mold and metallic part)
  - Better part (multi-materials, heterogeneous)

3DP, 3-Dimensional printing

- Process
  - Deposits a layer of powder object at top of build volume.
  - Deposits liquid adhesive (i.e. binder) to bond the powder particles together for the particular layer.
  - Fabrication piston moves down by one layer thickness, and the process is repeated until entire object is printed.
  - Object is removed from the fabrication chamber.
  - Further infiltration is applied during post processing to enhance the rigidity of the printed object.
  - No external support is needed since the powder bed supports overhangs by itself.
- Features
  - Fastest comparing with other 3d printing methods
  - Limitation on resolution, surface finish, part fragility and available materials

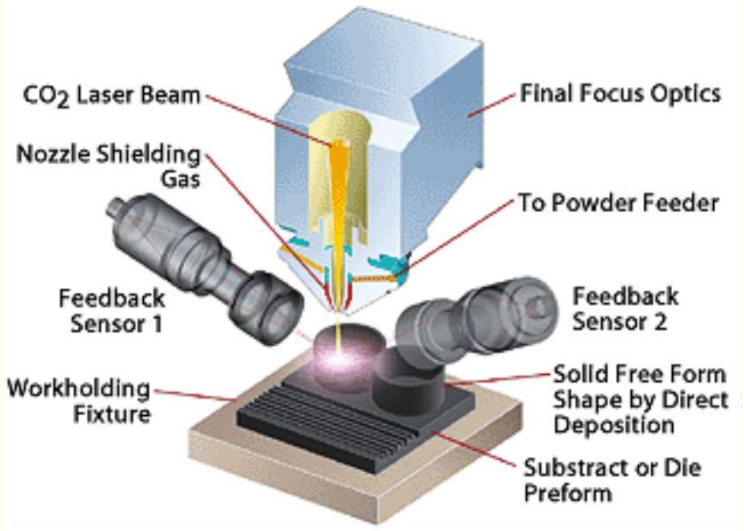
3DP, 3-Dimensional printing



DMD, Direct metal deposition

- High power laser builds parts layer-by-layer out of gas atomized metal powder
- Process
  - Focusing CO_2 laser beam onto a flat tool-steel workpiece or preformed shape to create a molten pool of metal.
  - A small stream of powdered tool steel is then injected into the melt pool to increase the size of the molten pool.
  - By moving the laser beam back and forth, under CNC control, and tracing out a layer pattern.
- Features
  - Tool steel, Aluminum, Ni-Alloy, Ti-Alloy, etc.
  - Molten pool cools and solidifies rapidly producing metal parts of superior quality and strength with no material waste.
  - Consistent, fine microstructures, with superior quality and tool strength

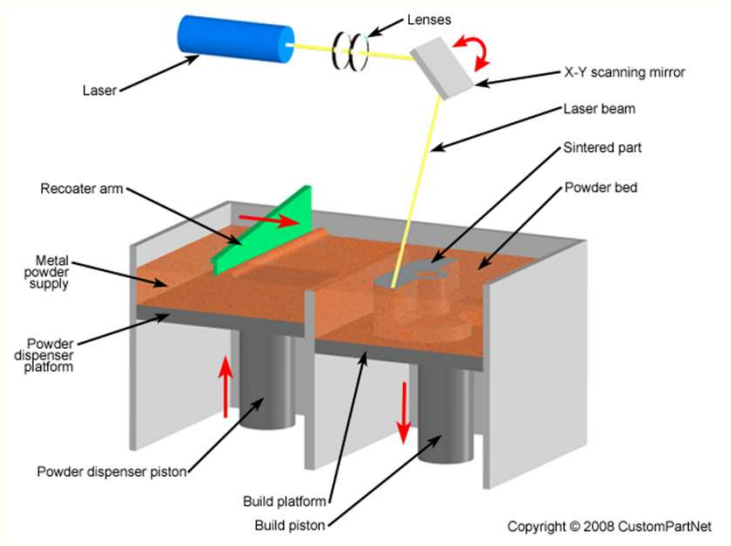
DMD, Direct metal deposition



DMLS, Direct metal laser sintering

- Uses a precise, high-powered laser to micro-weld powdered metals and alloys to form fully functional metal components
- Process
  - Recoater arm pushes build material from a powder supply to create a uniform layer over a build piston platform.
  - Laser scanning system literally draws the 2D cross section on the surface of the build material, sintering it into a solid form.
  - Build piston is lowered and the process repeats.
- Features
  - Inconel, Aluminum, Stainless Steel, and Titanium
  - Strong, durable, and heat-resistant
  - A surface finish comparable to a fine investment cast part
  - Secondary finishing operations, such as media blasting, electroplating, polishing, and CNC machining may be required.
  - Based plate and support structure for overhang is needed.

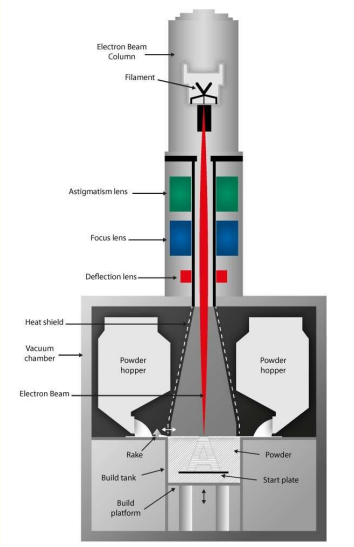
DMLS, Direct metal laser sintering



EBM, Electron beam melting

- Melting metal powder layer by layer with an electron beam in a high vacuum, which makes it suited to manufacture parts in reactive materials with a high affinity for oxygen.
- Process
  - Rake distributes a fine layer of metal powder across the build platform.
  - An electron beam melts the particles in the 2D slicing pattern.
  - Build platform lowers slightly, and the process repeats.
- Features
  - Titanium, Stainless steel, Aluminum, etc.
  - High-melting and/or highly reactive materials
  - Fully dense, void-free, and extremely strong
  - Minimal additional finishing

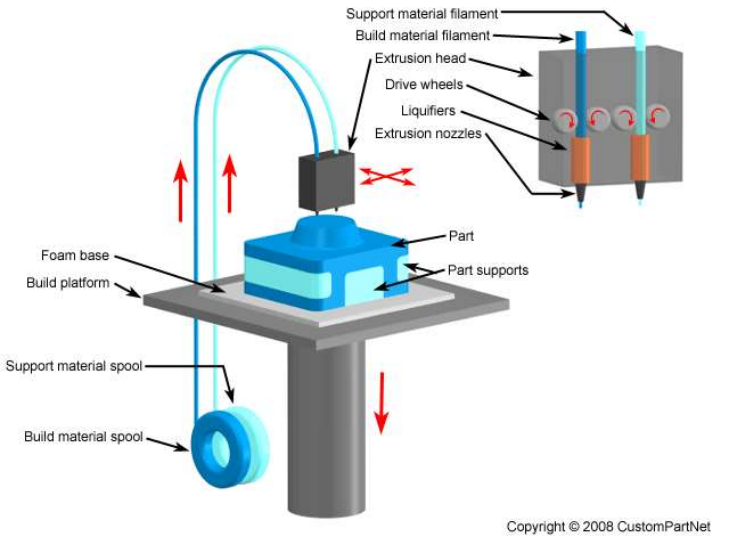
EBM, Electron beam melting



FDM, Fused deposition modeling

- Laying down consecutive layers of material at high temperatures, allowing the adjacent layers to cool and bond together before the next layer is deposited.
- Process
  - Filament is led to the extruder.
  - Extruder feeds and retracts the filament at precise amounts.
  - Heater block melts the filament to a usable temperature.
  - Heated filament is forced out the heated nozzle at a smaller diameter.
  - Print head and/or bed is moved to correct position and extruded material is laid down.
- Features
  - ABS. PLA, PC, Nylon, etc.
  - Support structure for overhang
  - Finished parts are anisotropic, i.e. different materials characteristics in different directions.
  - Resolution is not fine.

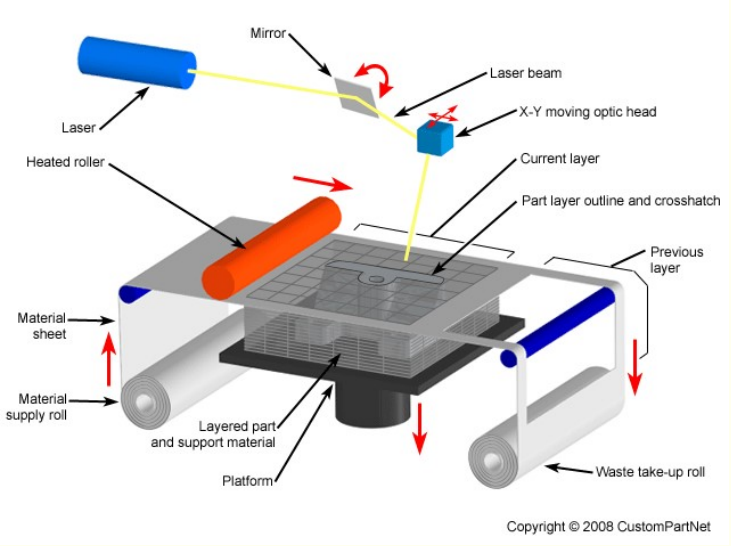
FDM, Fused deposition modeling



LOM, Laminated object manufacturing

- Uses a CO_2 laser to create successive cross-sections of a three-dimensional object from layers of paper with a polyethylene coating on the backside.
- Process
  - Sheet adheres to substrate with the heated roller.
  - Laser then traces out the outline of the layer.
  - Non-part areas are cross-hatched to facilitate removal of waste material.
  - Once the laser cutting is complete, the platform moves down.
  - Fresh sheet material rolls into position.
  - Platform moves back up to one layer and process repeats.
- Features
  - Paper sheet laminated with adhesive on one side.
  - Plastic and metal laminates are appearing.
  - Excess material supports overhangs and other weak areas.
  - Sealed with a paint or lacquer to block moisture ingress.

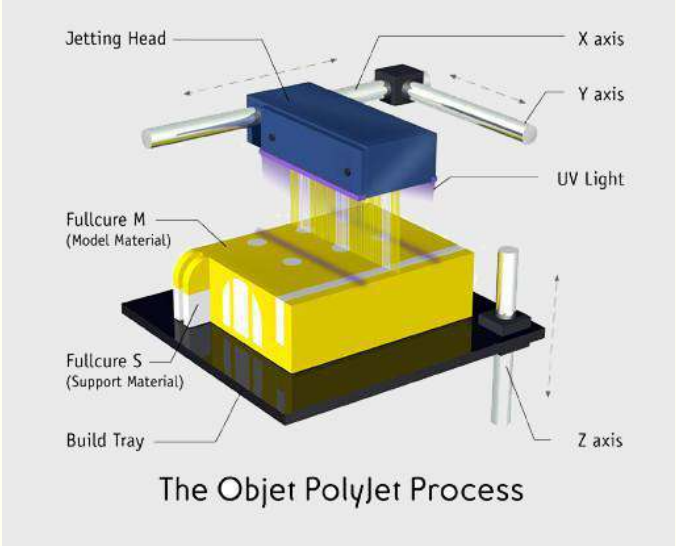
LOM, Laminated object manufacturing



PolyJet, Polymer jetting

- Jet layers of curable liquid photopolymer onto a build tray.
- Process
  - A wide area inkjet head deposits both build and support materials.
  - Subsequently completely cures each layer after it is deposited with a UV flood lamp mounted on the printhead.
  - Support material is removed by washing it away with pressurized water in a secondary operation.
- Features
  - Acrylic based photpolymers, Elastomeric photopolymers.
  - Smooth, detailed prototypes, color and diverse material properties.

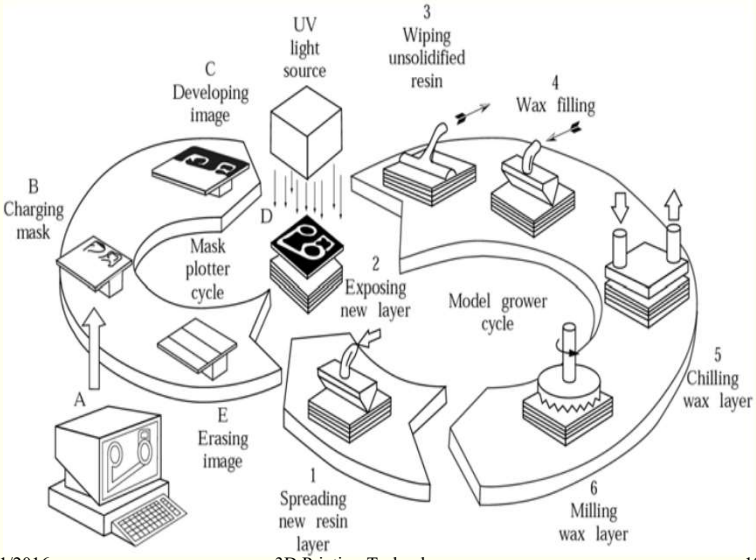
PolyJet, Polymer jetting



SGC, Solid ground curing

- Layer geometry is carried out by means of a high-powered ultra violet (UV) lamp through a mask.
- Process
  - Optical mask is generated conforming to each cross section.
  - A thin layer of liquid photopolymer covers the build area.
  - The optical mask is positioned over the surface of the liquid resin, and the resin is exposed to a high-power UV lamp.
  - Residual liquid is removed from the workpiece by an aerodynamic wiper.
  - A layer of melted wax is spread over the workpiece to fill voids. The wax is then solidified by applying a cold plate to it.
  - The layer surface is trimmed to the desired thickness by a milling disk. The process repeats.
  - The wax is melted away upon completion of the part.
- Features
  - Photopolymers.
  - Good accuracy and a very high fabrication rate.

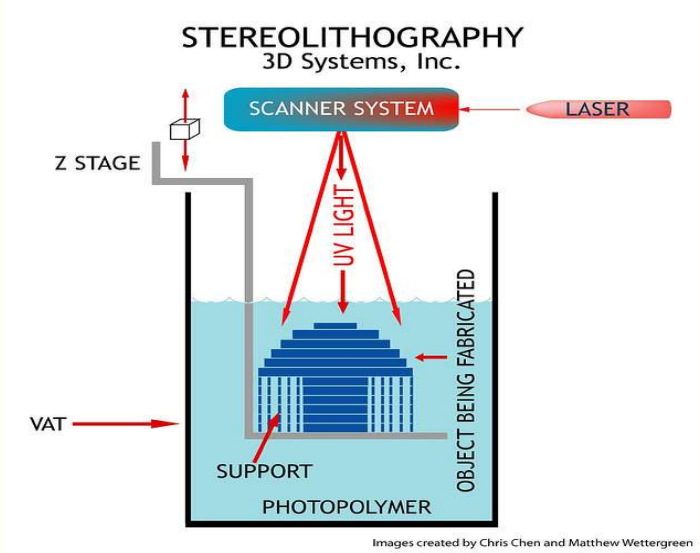
SGC, Solid ground curing



SLA, Stereolithography

- By tracing a laser generating U-V beam on the surface of a vat of liquid photopolymer.
- Process
  - A thin layer of is exposed above the perforated platform.
  - UV laser hits the perforated platform to "paint" the pattern, and UV-curable liquid hardens instantly.
  - Platform is lowered to expose the next layer of liquid polymer.
  - Again traces a cross section, which instantly bonds to the hardened section beneath it. The process repeats.
  - Rinse with a liquid solvent to free it of excess resin, and bake in an ultraviolet oven to further cure the plastic.
- Features
  - Photopolymers.
  - Support is needed for overhang and/or undercut.
  - Generally have great accuracy and smooth surfaces.

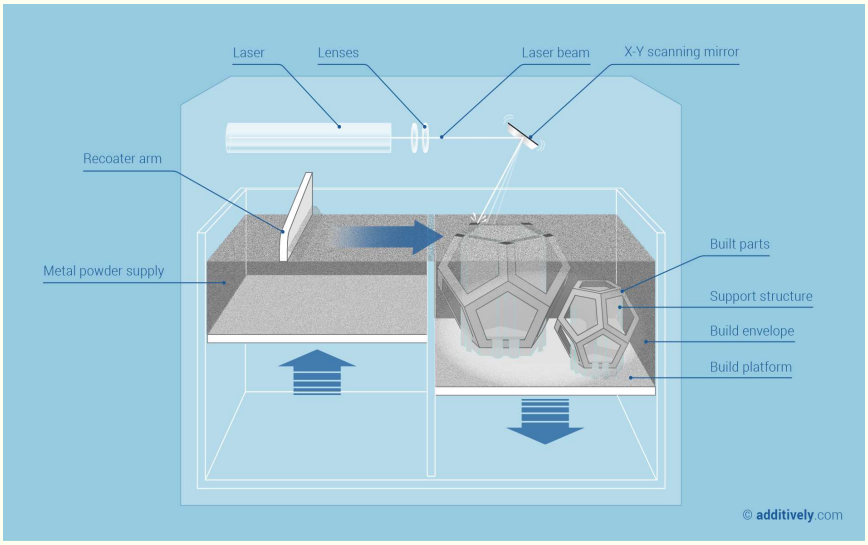
SLA, Stereolithography



SLM, Selective laser melting

- Selectively melts thin layers of fine metal powder inside a chamber containing a tightly controlled atmosphere of inert gas, either argon or nitrogen.
- Process
  - Recoater sweeps a layer of fine metal powder from powder room to building chamber.
  - Laser beam melts the designated areas to form the sliced part.
  - Platform is lowered by the respective thickness, and another layer of powder can be applied.
- Features
  - High quality steels, Titanium-, Aluminum-, Nickel-based alloys.
  - No support for overhang and/or undercut is needed.
  - Allow the parts to uniformly come to a low-enough temperature that they can be handled and exposed to ambient temperature and atmosphere.

SLM, Selective laser melting



SLS, Selective laser sintering

- High-powered laser to sinter powdered material.
- Process
  - Roller pushes build material from the powder supply to create a uniform layer over the build piston.
  - Scanning system then draws the 2D cross section on the surface of the build material, sintering the material.
  - Build piston is lowered as the powder delivery piston is raised and a new layer of material is placed in the build volume.
- Features
  - Nylon, TPE, Glass, Ceramics, Metal.
  - No support for overhang and/or undercut is needed.

SLS, Selective laser sintering