Presentation On Water Less Technologies and 3D Printing

By

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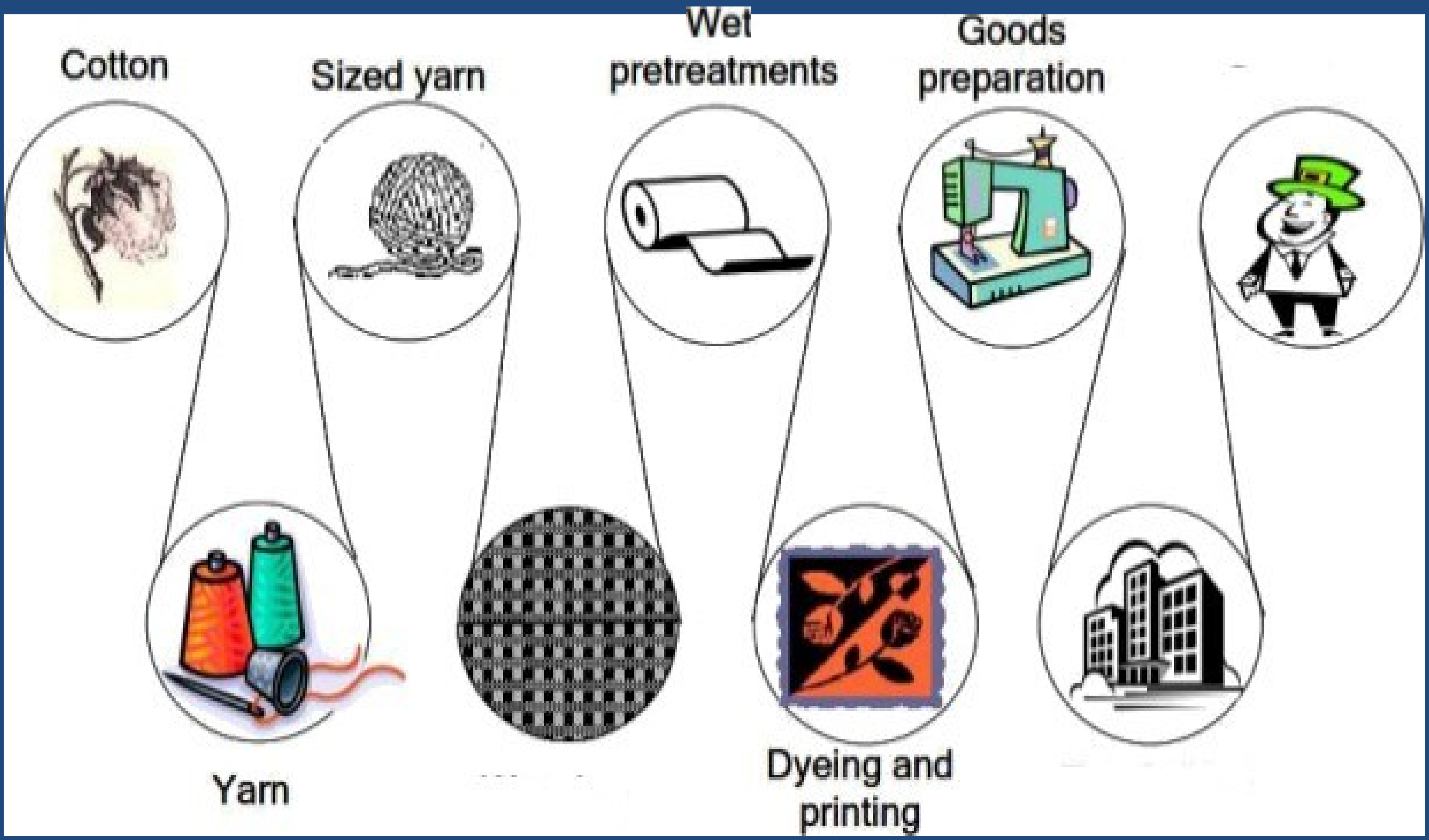
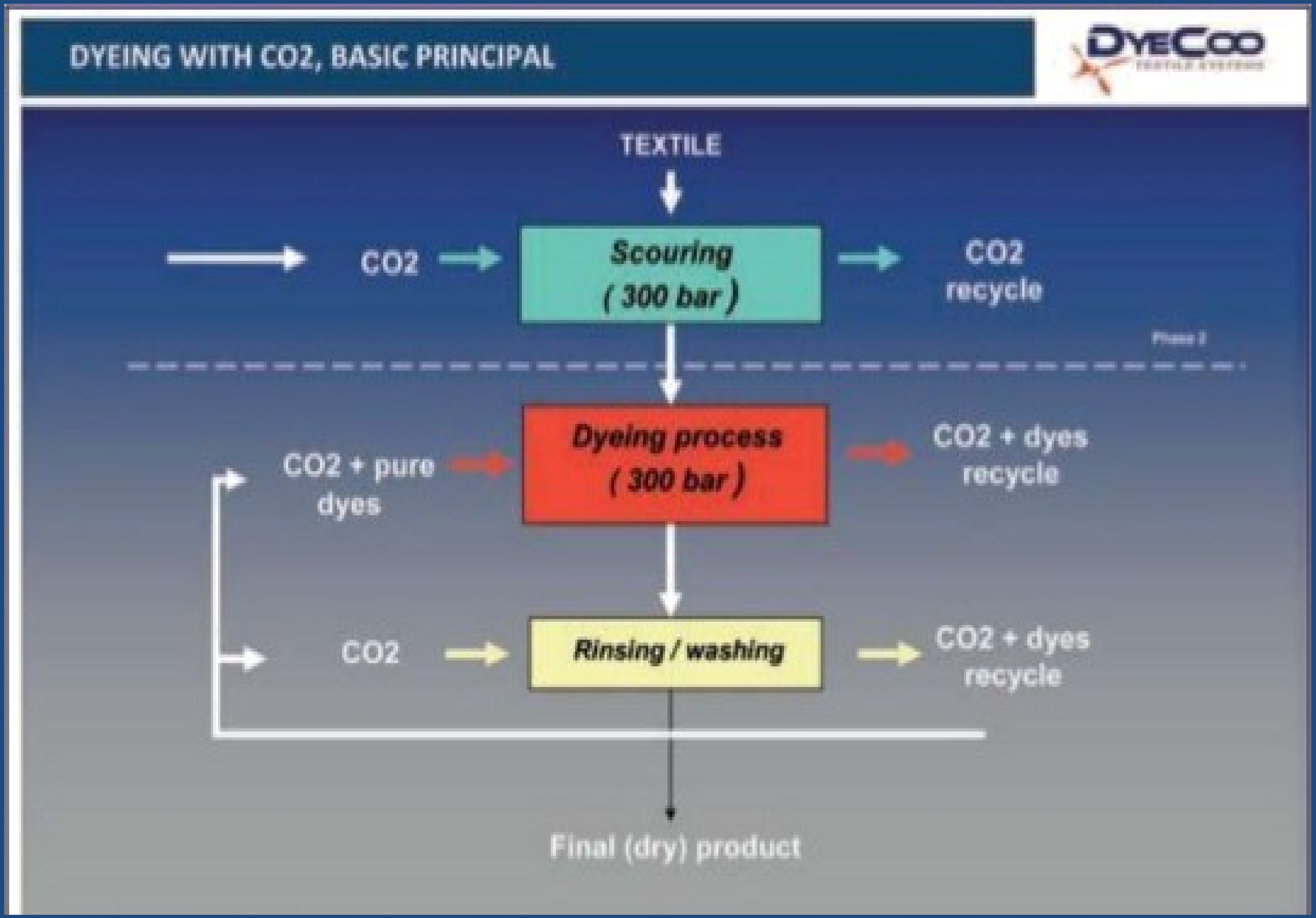
Total Textile Process At A Glance



Prologue

- The textile industry is the biggest consumer of water.
- An estimated 100-150 liters of water is needed to process 1kg of textile material, with some 28 billion kilos of textiles being dyed annually.
- Water is used as a solvent in many pretreatment and finishing processes, such as washing, scouring, bleaching and dyeing.
- Doing away process-water and chemicals would be a real breakthrough for the textile dyeing industry.
- With the launch of the world's first ever industrial dyeing machines that uses super carbon dioxide (COC) as a replacement for water.
- Dutch company, DyeCoo Textile Systems BV. introduced this , completely water-free dyeing process having considerable lower operational costs compared to conventional dyeing processes.

Basic Principle



Advantages

Conventional Dyeing	Dyeing in SC CO_2
High volume of waste water with residual dye chemicals	No waste water Dye remains as powder No need for dispersing & leveling agents
High energy requirement	Only 20% energy required
Dyeing /washing, drying times are 3-4h/batch	Only 2h

What is super critical fluid

- A supercritical fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do not exist. It can effuse(spill , shed) through solids like a gas, and dissolve materials like a liquid.

- Close to the critical point, small changes in pressure or temperature result in large changes in density, allowing many properties of a supercritical fluid to be "fine-tuned".

- Supercritical fluids act as a substitute for organic solvents in a range of industrial and laboratory processes. Carbon dioxide and water are the most commonly used supercritical fluids, being used for decaffeination and power generation, respectively.

- Carbon dioxide is a readily available, cheap, recyclable and is non-toxic and non- flammable. Above the temperature of 31.6°C and pressure of 73 atm carbon dioxide exhibits physical properties, which are intermediate between those of gases and liquids.

- These conditions are called supercritical conditions and are readily achievable using commercially available equipment. Supercritical carbon dioxide is able to dissolve a range of chemical substances including organic substrates, catalysts, and light gases.

- Its advantage is that this solvent can be easily turned into a gas by simply releasing the pressure leaving no solvent residues and requiring no evaporation or separation.

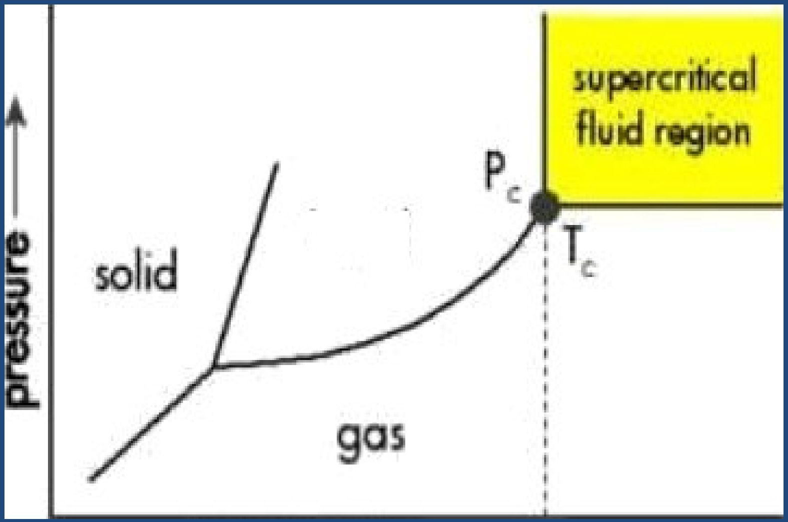
- **Other attributes of carbon dioxide are :**
- It is virtually an inexhaustible resource (atmosphere, combustion processes, and natural geologic deposits).
- It is not only biodegradable as a nutrient promoting the growth of plants, but is an essential element of natural processes.
- It does not affect the edibility of food stuffs and will only have toxic effects at extremely high concentrations.
- It has no disposal problems. It is recovered from the process in the form of an uncontaminated gas and can be reused.
- It is easy to handle and non combustible.
- It has a critical point with in the range which is readily manageable by technical means (31°C and 73 bar).
- It is non-toxic, non-hazardous, nonflammable non-corrosive and low cost.

Benefits

- Applied as a clean solvent
- Improved control and fine-tuning of process
- Developed as a remarkably selective synthetic process
- Minimized waste & increased atom utilization
- Minimized handling and purification procedures

Properties

- Low cost
- Non-Toxic
- Density : liquid
- Viscosity: Gas
- Recycling up to 90%
- Inert
- Non- explosive
- Low critical point
- Pressure: 73.858 + 0.005 bar
- Temperature: 31. 05 + 0.05 °C



Chemistry of Dyes

- Reactive dyes(VS-dye), for cotton, rayon, silk, and wool form stable chemical links with textile materials to produce colored fabrics with excellent overall fastness, other dyestuffs form only loose bonds with fibers.

- Acetate, nylon, and polyester fibers colored with dispersed dyesES-Dye) retain their color even after repeated exposure to sunlight and washing.

(Courtesy SASMIRA, Mumbai)

Dyeing Procedure

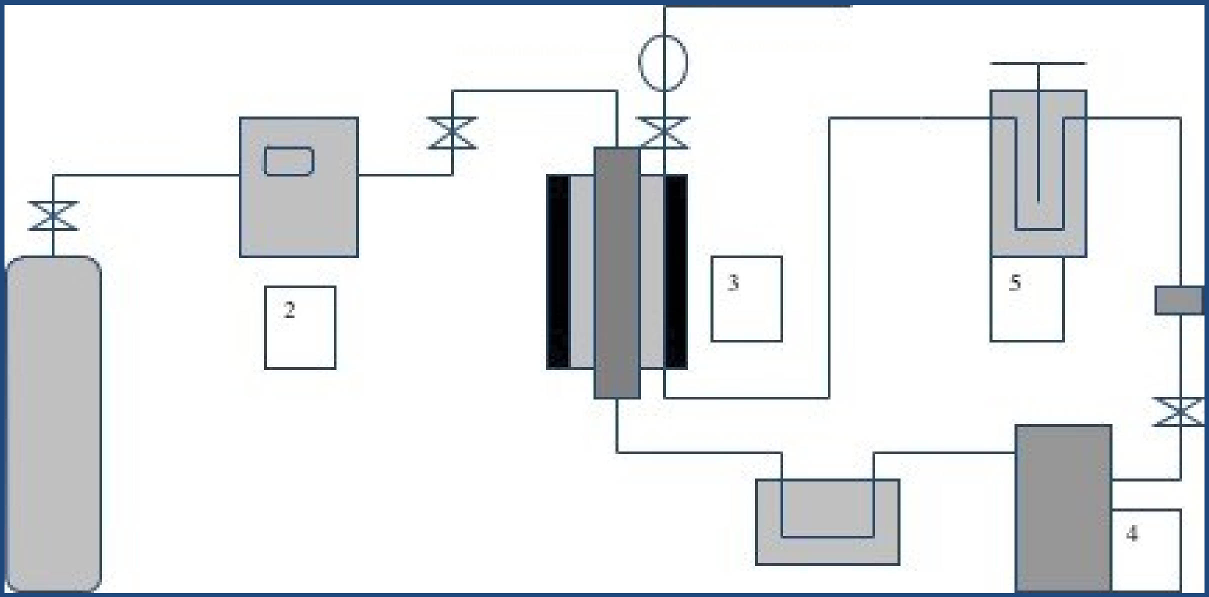
- Add fiber and dye to vessel
- Pressurize system (with Carbondioxide) up to 800 psi and stir at approximately 850 rpm
- Heat to required temperature (100 -180 °C)
- Pressurize to 3500 psi; hold for 2 hours
- Release pressure, remove fabric

(Courtesy SASMIRA, Mumbai)

Dyeing Procedure

CO_2 , Dyeing System

1. Gas cylinder of CO_2
2. High pressure pump
3. Autoclave reactor vessel with stirrer
4. Circulation pump
5. Electrical heating jacket



Testing Dye-Fiber Reaction

- Measure color strength (K/S) of each dyed fiber
- Wash Fiber with acetone (remove surface dye)
- Conduct soxhlet extraction using ethyl acetate (to remove unreacted dye)
- Compare effect of vinylsulfone reactive group on dye fixation

(Courtesy SASMIRA, Mumbai)

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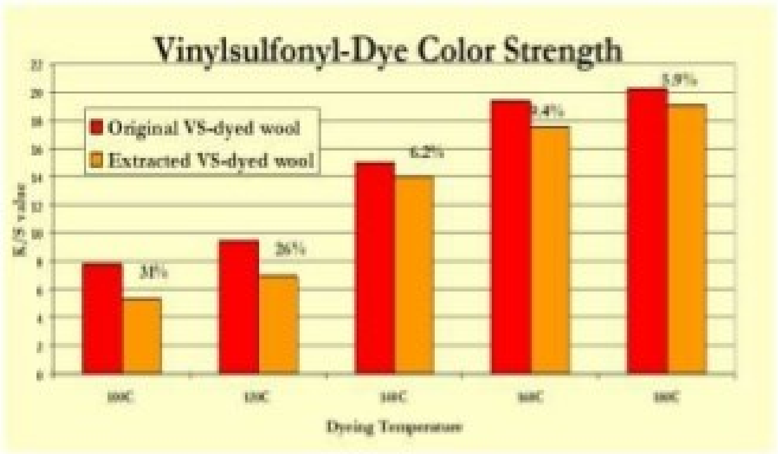
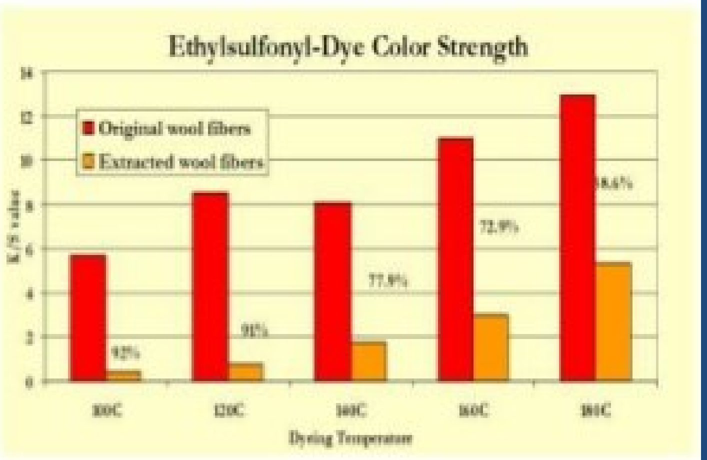
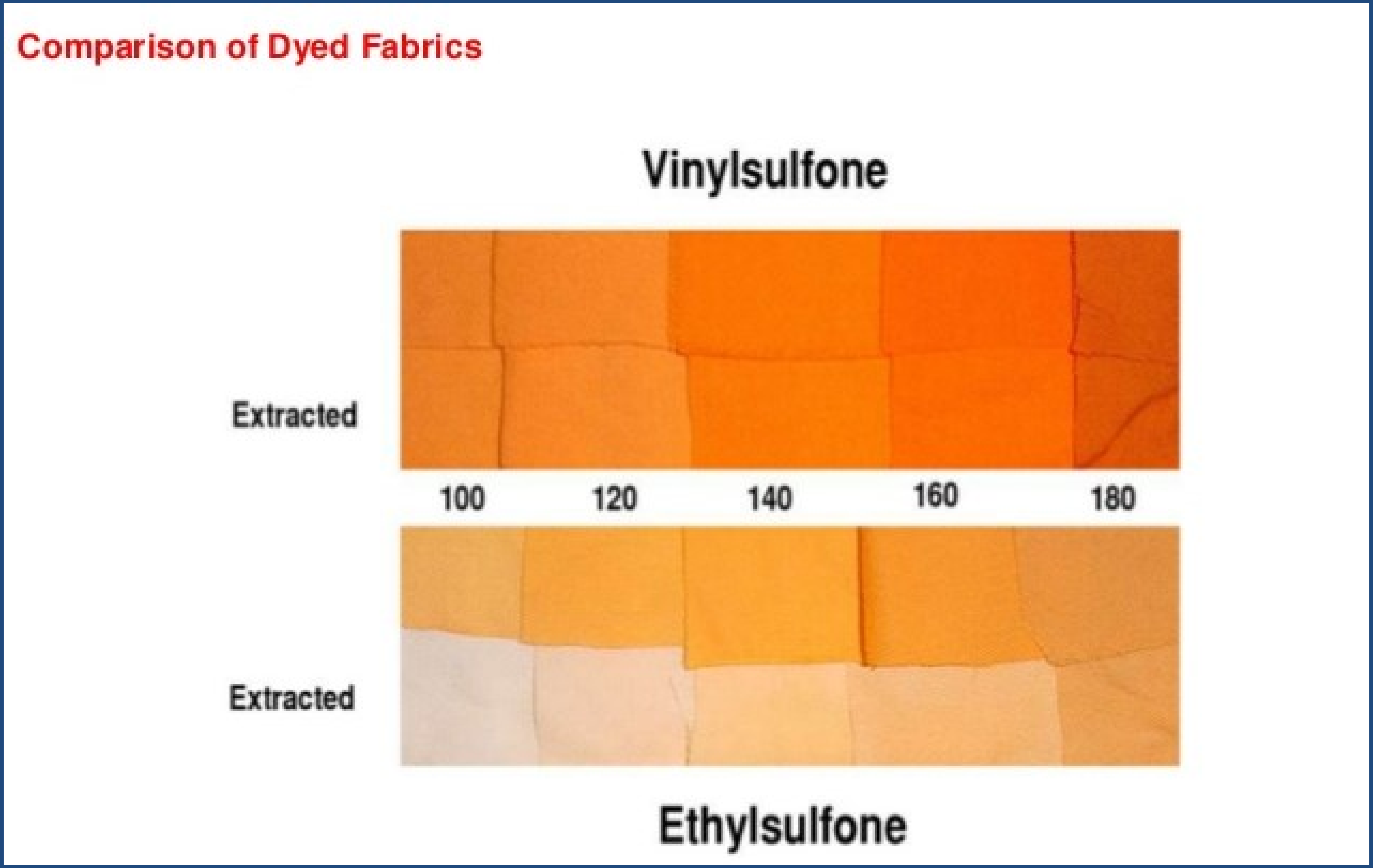
Results





(Courtesy SASMIRA, Mumbai)



(Courtesy SASMIRA, Mumbai)

Observation

- Color depth improved with increasing temperature
- Strong evidence for dye-fiber bond formation using vinyl sulfone-based dye on nylon and wool
- ES-dyeing on wool fibers showed extremely low color yields after extraction.
- 94% fixation at 180 °C/ 3500 psi on wool

(Courtesy SASMIRA, Mumbai)

Polyester Dyeing with SC Carbondioxide

Advantages:

- Elimination of usage of water, water treatment and water pollution Elimination of a drying step, thus reduces energy cost.
- Elimination of auxiliaries, such as, dispersing agent, leveling agent
- Rapid dilution and potential for high degree of dye exhaustions
- Dyeing occurs with high degree of levelness
- No after treatment is required
- Time required for dyeing is very less
- Gives good rubbing fastness
- Dyeing houses may be started on sites where there is water scarcity
- No air pollution due to recycling of CO, is accomplished
- Economical and environmentally friendly.

Water & Soil Repellent Finishing on Textiles

For water & soil repellent finishing on textiles various chemical solutions can be applied, of which perfluorocarbon (PFC) chemistry has become state of the art in performance.

But this chemical substance class is under critical observation **due** to their toxicity and persistence in the environment

Alternative, PFC- technologies for water and soil repellency

1. Short-chain fluoro alkyl compounds, such as C_6 PFCs
2. Silicones
3. Paraffins
4. Stearic acid-melamines
5. Dendrimers
6. Micro-scaled surfaces

Recent Subjects In Textile Finishing

- Nano finishing
- Microencapsulation
- Phase change materials
- Plasma treatment
- Application specific technical textiles
- Composites structures
- Non- aqueous or low water finishing
- Biotechnology
- Technical natural fibers and biodegradable products!
- Development in traditional finishing processing

Textile Nano Finishing

- **Nano sphere finish- from Clariant and Schoeller Technologies AG. Textile materials finished with Nano sphere repel liquids and dirt, and stains from kethch up, oil and red wine run off the surface.**
- **'Nano- Plem' technology by Toray, Japan. This imparts water- repellant characteristics and color resilience to nylon and polyester fabrics and Terylene/ wool blends.**
- **Mincor TX TT, a nano finish from BASF, is a composite material with nano particles embedded in a carrier matrix. This finish provides solution for the fabrics like polyester awning, sunshades, flags and sails that remain continuously in outdoor environment; hence can not be cleaned in washing machine.**
- **Synthetic fibers can be made soft and comfortable like cotton. Nano- TouchTM fabric technology grafts permanently an outer layer of cotton- like properties around a synthetic fiber core.**

Nano metals and nano metal oxide based finishes

- **Properties of metal nano particles and metal oxide nano particles to interact light and microorganisms offer substantial desired effects in textiles and fiber finishing.**

- **Use the nano particles that are risk- free during their life cycle (production, application, consumption, and disposition).**

- **Metal based nano finishes Nano silver particles impart antimicrobial properties, and metal oxides produce flame retardancy, UV blocking and self- cleaning properties.**

- **Disadvantages with the nano silver are high cost, incompatibility to aqueous systems and tendency to cause discoloration in textiles.**

Textile Nano Finishing

- **Metal oxide nano finishes-** Organic embedded metal oxide; ZnO nano particles, with average size of 38 ± 3 nm using TEM, dispersed into soluble starch matrix using water- based technique. The treated cotton fabric exhibited significant improvement in antibacterial activity against *Staphylococcus aureus* and *Klebsiella pneumoniae* cultures and UV radiation.

- For clothing textiles a concentration of nano- ZnO of 0.6 wt. % for UV protection, and for antimicrobial textiles 1.0 wt. % concentration were recommended.

- Nano grade TiO2 during the melt extrusion of nylon 6.6 improved mechanical properties. TiO2- nylon composite fibers exhibited increased resistance against photo- tendering on exposure to artificial day light up to 750 hours.

- Nylon 6.6 & nylon6 and Kevlar fabrics treated at 5 wt. % of TiO2 nano particles dispersed in acrylate and ethanol, enhanced UV protection .

- Biological protective textiles can be produced using nano particle form of TiO2 and MgO.

Microencapsulation Finishes As Potential Areas

- **Thermoregulation (PCM)**
- **Aromatherapy, fragrance release**
- **Deodorizing finishes, biocides**
- **Antisoiling agents**
- **Insect resisting finishing**
- **UV absorbers, antistatic agents**
- **FR, water repellants**
- **Cross- linking agents, softeners, chemical protection, etc., etc.**

Clay Finishing

- Polymers reinforced with 2-5 wt% of nano clays exhibit significant improvement in thermal & mechanical properties, flame retardancy, barrier properties, dimensional stability and modified electrical conductivity.

- Nylon-6 nano composite reinforced with 5 wt % of nano clay resulted in 40% increase in tensile strength, 68% in tensile modulus, 60% in flexural strength, and 126% flexural modulus. The heat distortion temperature increased from 65 to 152 °C.

- Tensile properties and fire performance of polypropylene thermoplastics using functionalized nano clays improved significantly. In fiber, filament or fabric, this polymer needs to be explored.

- Montmorillonite is a clay mineral mainly used in producing nano clay- based finishes.

- The commercial viability of nano clays is due to their reduced cost, wider applicability to most synthetic polymers (PP, TPO, PET, PE, PS, polyamide), and performance enhancement in end- product.

3D Printing

U.S. President Mr. Barack Obama stated in his State of the Union address a year ago: "3D printing has the potential to revolutionize the way we make almost anything".

3D Printing

3D printing process is a type of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is also called as prototyping.

Creativity

Create a unique design with wide array of product choices

Convenience

Ability to print out objects right in front of your eyes

Development

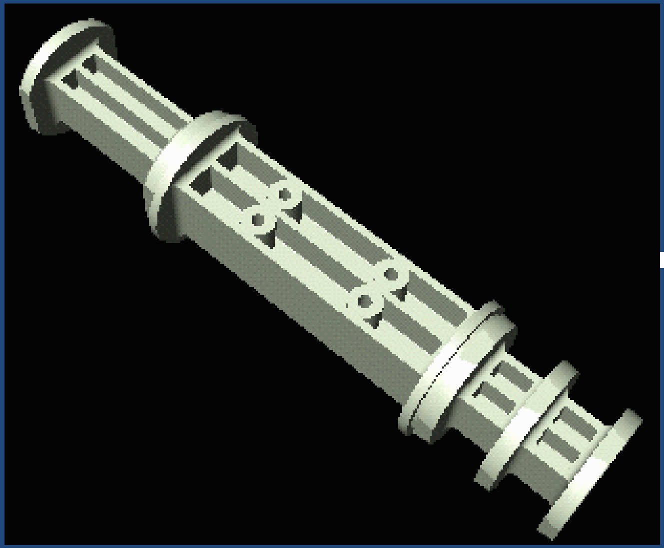
This manufacturing process is adapted worldwide

Benefits

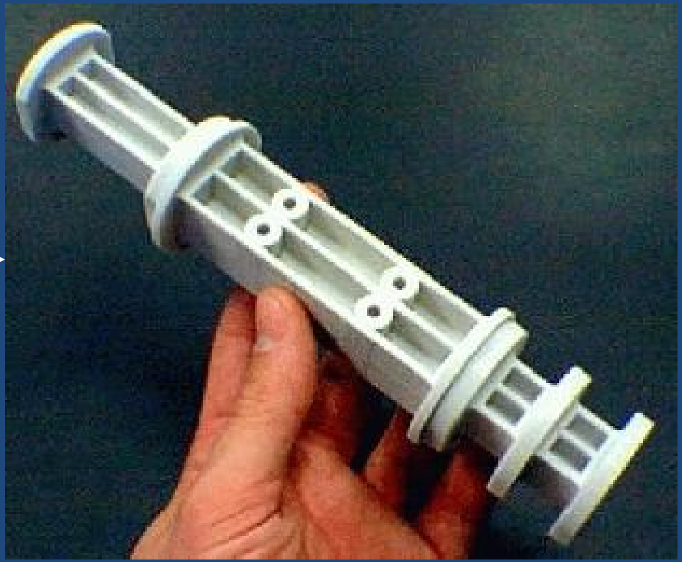
- Continue to grow rapidly in the market
- Become more consumer friendly
- Transform the manufacturing process
- Be used in many different ways

Typical Model

3D Printing refers to a relatively new class of manufacturing methods which quickly produce physical prototypes from 3D CAD data



CAD Model



Prototype from 3D Printing

Also known as *rapid prototyping, layered manufacturing* or *additive manufacturing*

- Capabilities of 3D printing hardware are evolving rapidly. They can build larger components and achieve greater precision and finer resolution at high speeds and low costs.
- Possible to create complex shapes and structures that were not feasible before.
- Salient feature of additive manufacturing is the marginal cost of a producing a second object is no different to the marginal cost of producing the 100000^{th}.
- The reduction or elimination of the cost of capital equipment can reduce lead times.

- Elimination of waste & cleaner production process.
- For instance, Boeing F18 fighter jets are printed in one process, rather than built in parts and then assembled. F18 have been built this way for the last 14 years and they are yet to have a failure

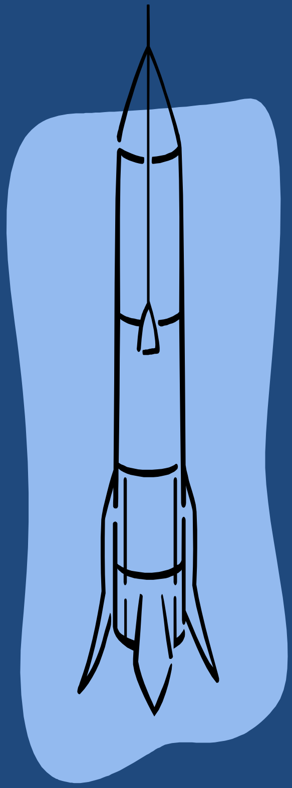
Limitation:

- High Prices :Cheapest printer $1,299
- Extra Fees :Must purchase designs
- Limited Materials :Most printers are restricted to plastic

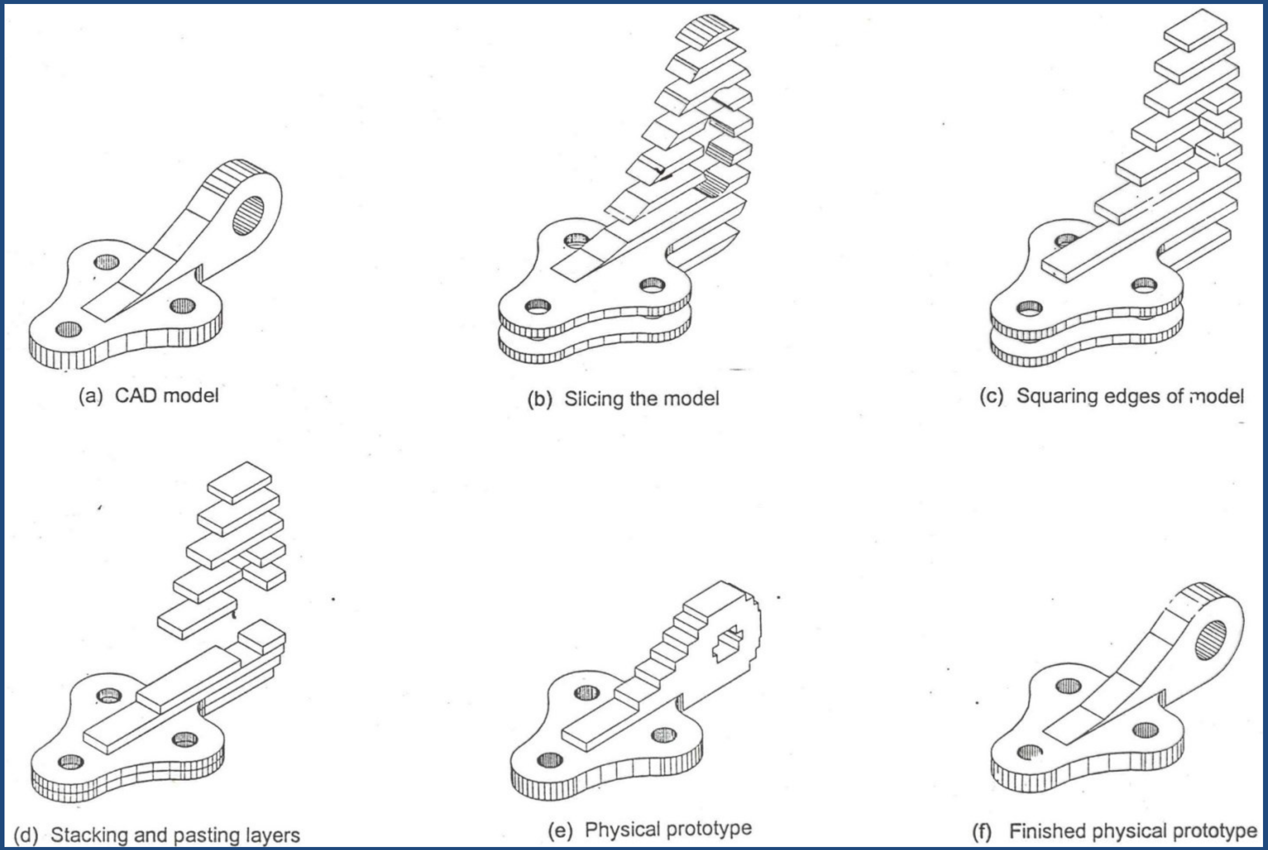
Uses of 3-D Printing

- Interesting topic because this technology could transform several aspects of business, research, and consumer needs

Industry	Medicine	Aerospace	Fashion	Home Decor
Use	Human organs	Producing spacecraft parts	Dresses, jewelry, and shoes	Lamps



3D Printing



3D Printing Processes use layer by layer addition

How Does 3D Printing Work

- Additive manufacturing: one layer at a time
- Common methods for producing layers:

  FDM, SLS, SLA

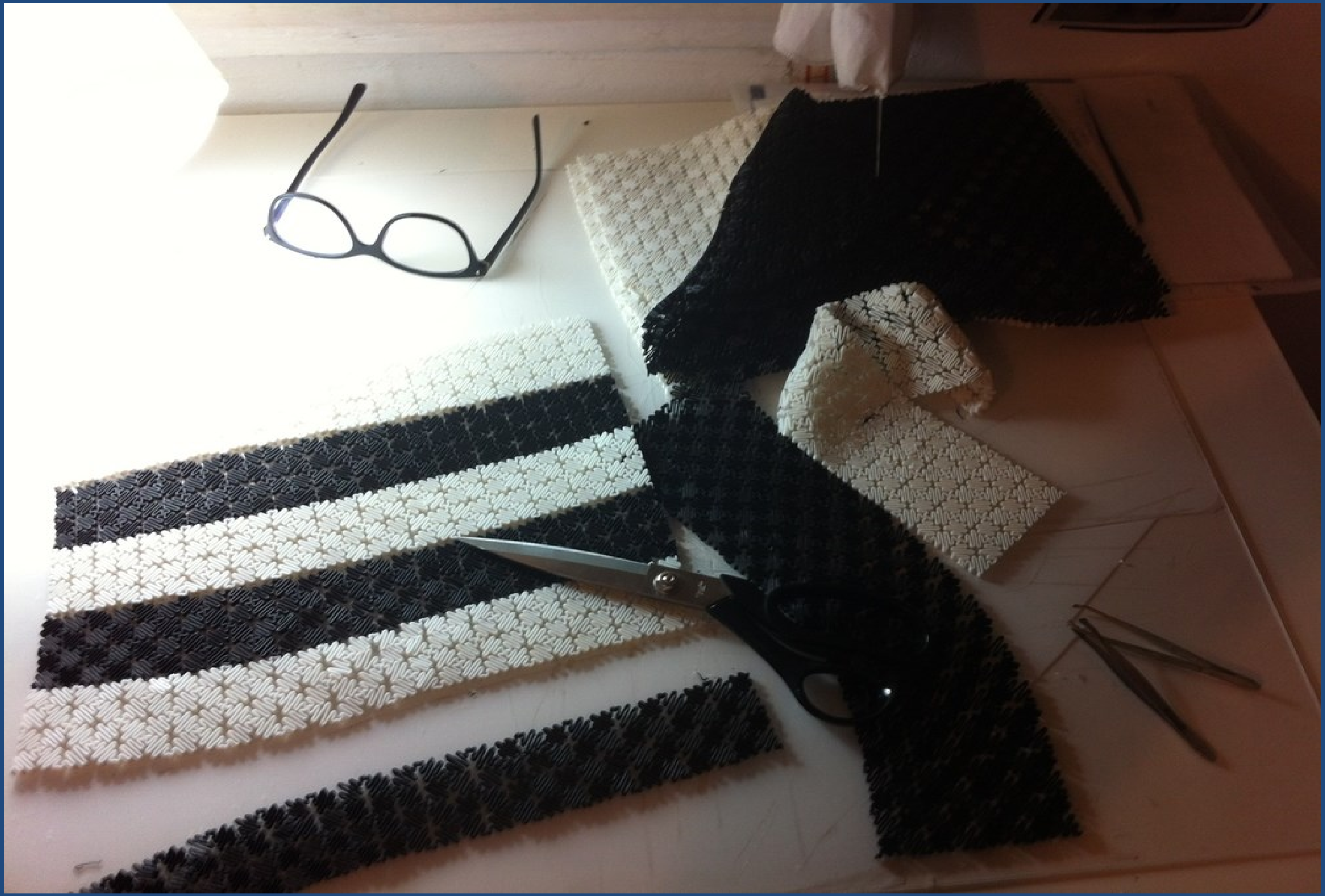
  FDM : fused deposition modeling

  SLS : selective laser sintering

  SLA : stereolithography

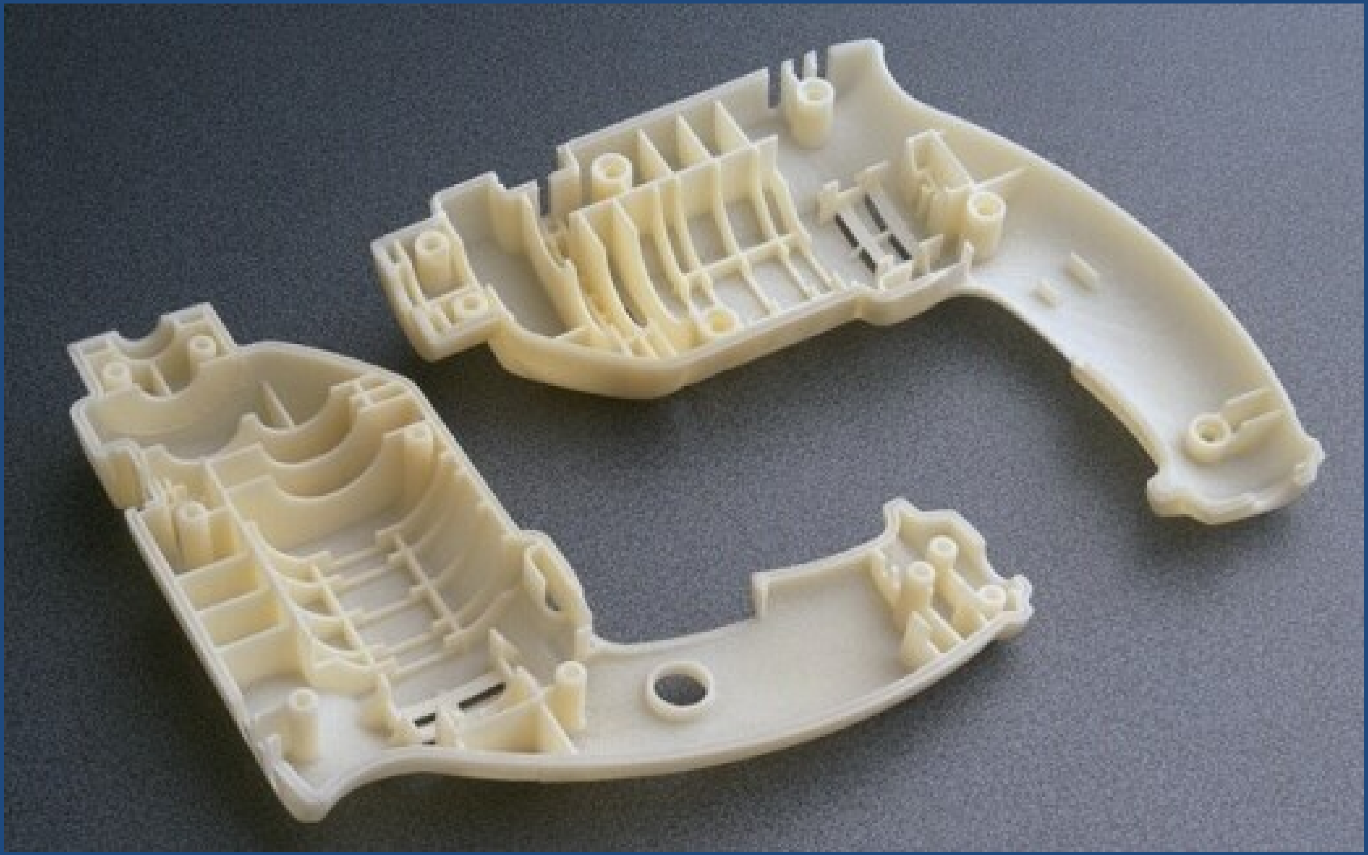
3D Printing in Textiles

- 3D printing solutions in the textile and clothing only to create 3D effects.
- Robes and gowns were created in the additive manufacturing method.
- But a real breakthrough is not yet attained in this sector.
- The textile machinery industry restricts itself to prototype 3D printing. It is time to print parts for textile machinery according to the new technology.
- 3D printed undergarment made in three seconds by British Tamicare under the brand of Cosyflex, a feminine hygiene product. It is bio-degradable, completely customizable fabric, comes in any desired shape with no fabric waste.
- It uses spray technique. Liquid latex, cotton or other fibers are seamlessly extruded to form layers of breathable fabric, ideal for sportswear, bandages and undergarments.
- The machine can chum out a pair of briefs in less than three seconds, meaning 10 million can be made annually.




YoGa GiRl
Design Jeans
49
Sport
Design Button Down Shirts
Design T-Shirts

3D Printing



3D Printing does not require any mold as a precursor to manufacture

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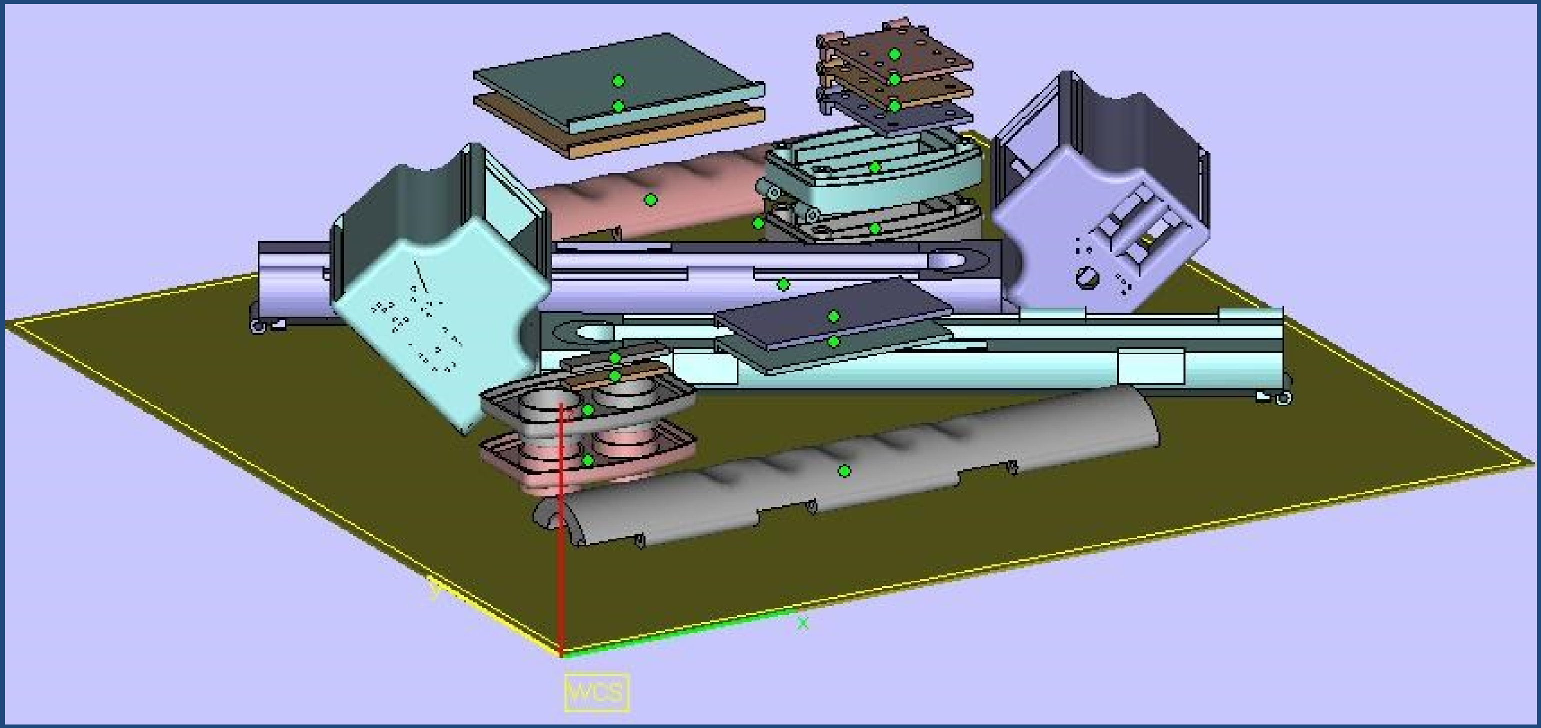
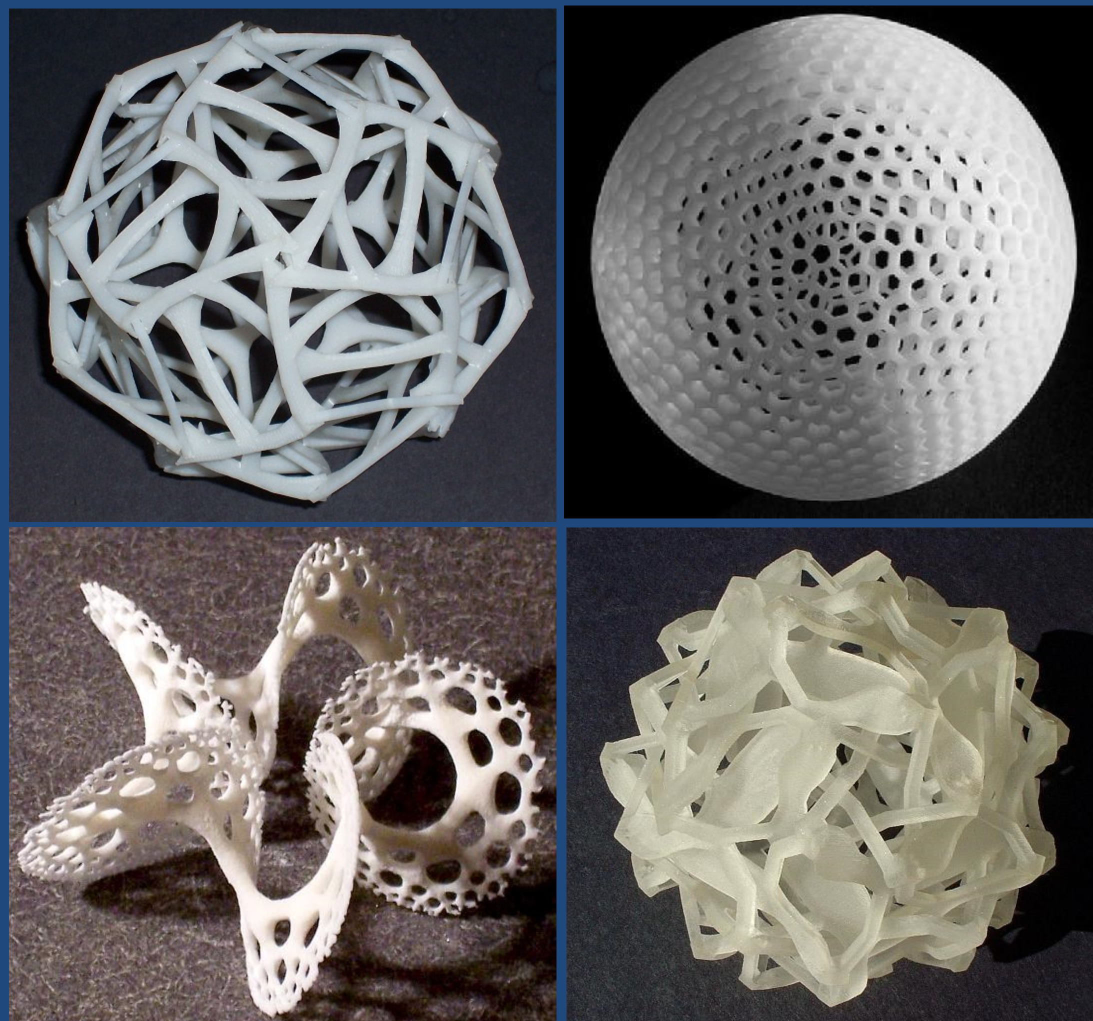


Multiple parts can be produced in one cycle

3D Printing



Geometric complexity is not a limitation in 3D Printing

Variations of 3D Printing Technology

SLA – Stereolithography

-UV light used to "cure" (harden) photosensitive resins or "photopolymers."

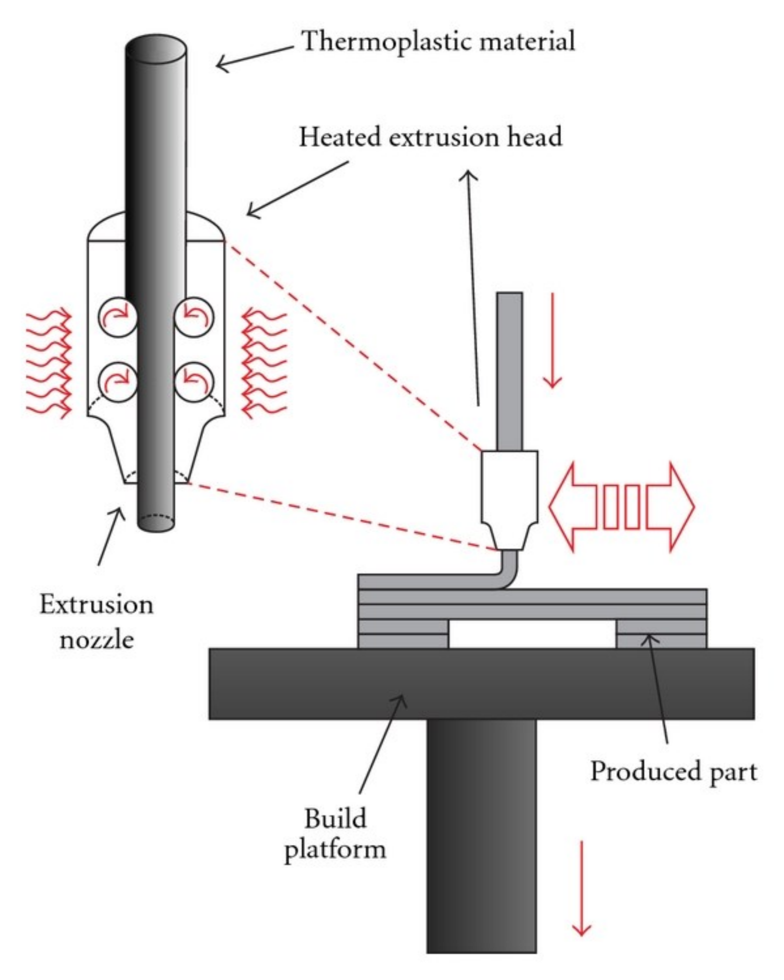
FDM, FFF, PJP – Fused Deposition Modeling, Fused Filament Fabrication, Plastic Jet Printing

-Melted plastic filament pushed through a nozzle or "extruder." Common plastics are ABS and PLA (polylactic acid, a bioplastic)

Powdered Bed – SLS or Selective Laser Sintering is the most common:

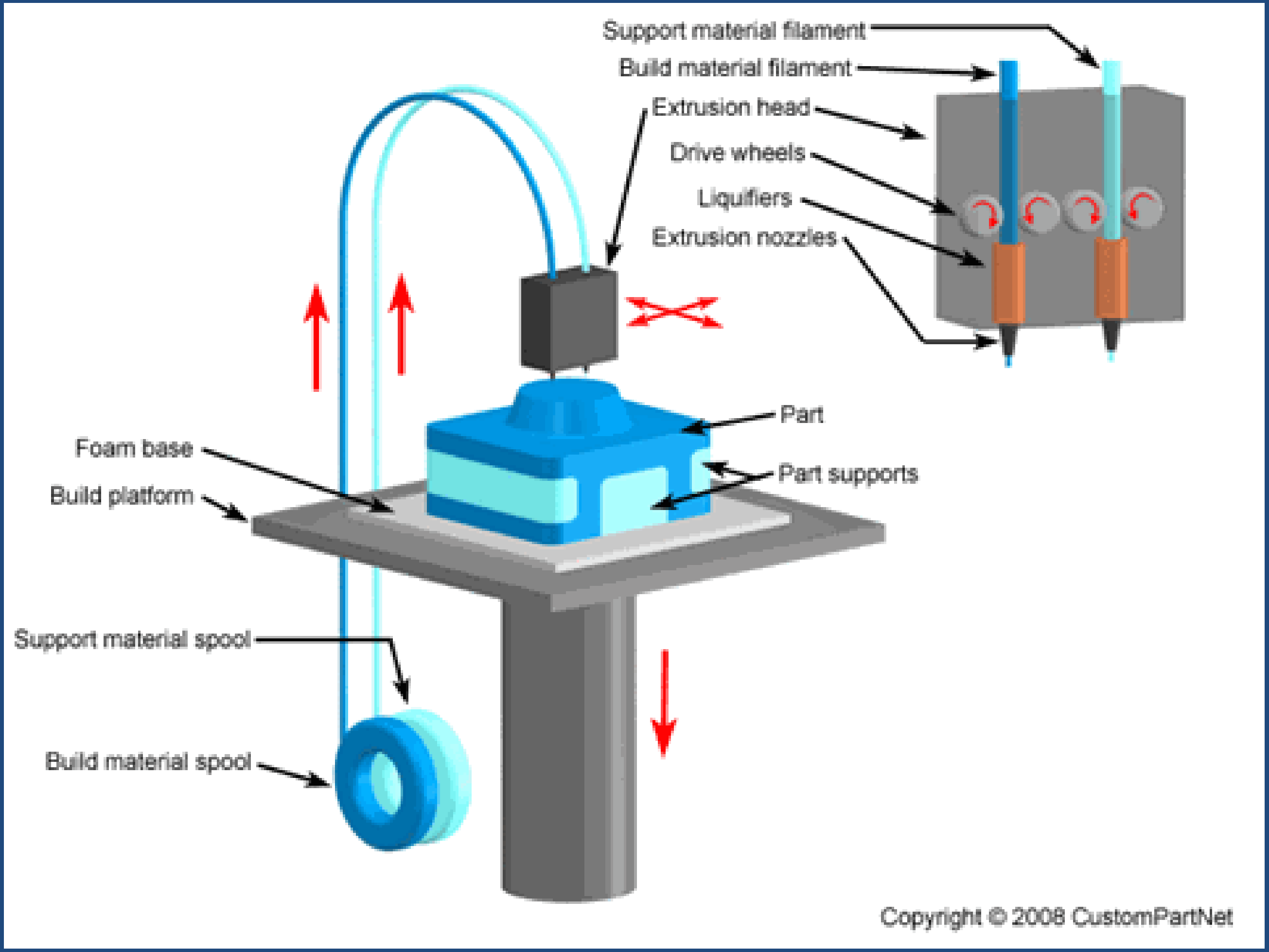
-A granular bed of materials as metal alloys, metal powders, thermoplastics, ceramic powders are selectively fused together by a laser.

3D Printing



Fused Deposition Modeling (FDM)

Rapid Prototyping

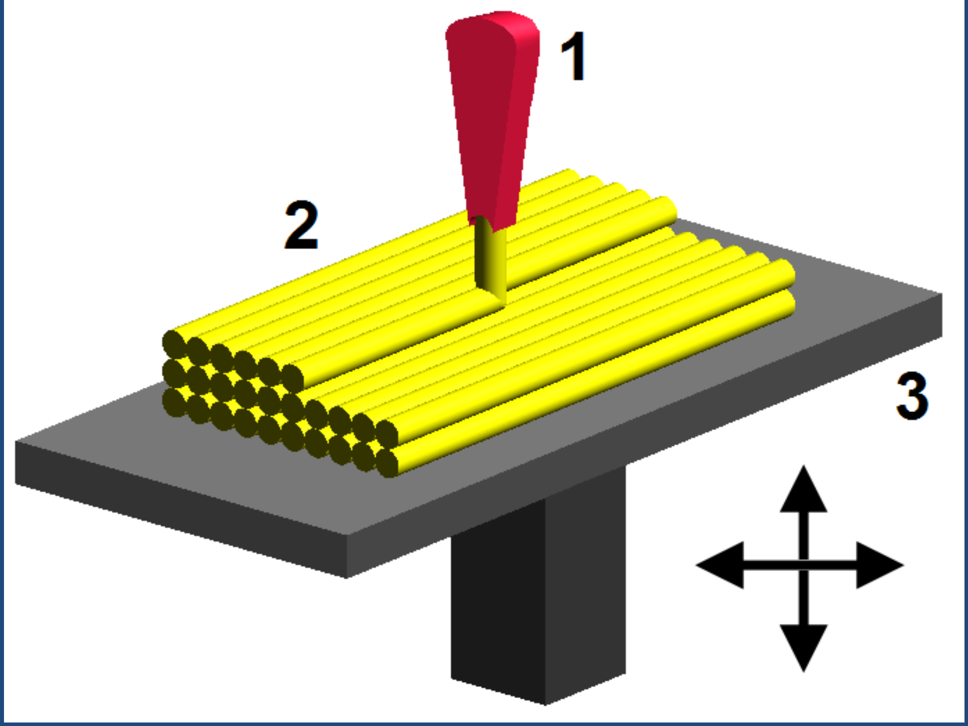


Fused Deposition Modeling (FDM)

Categories of Additive Manufacturing

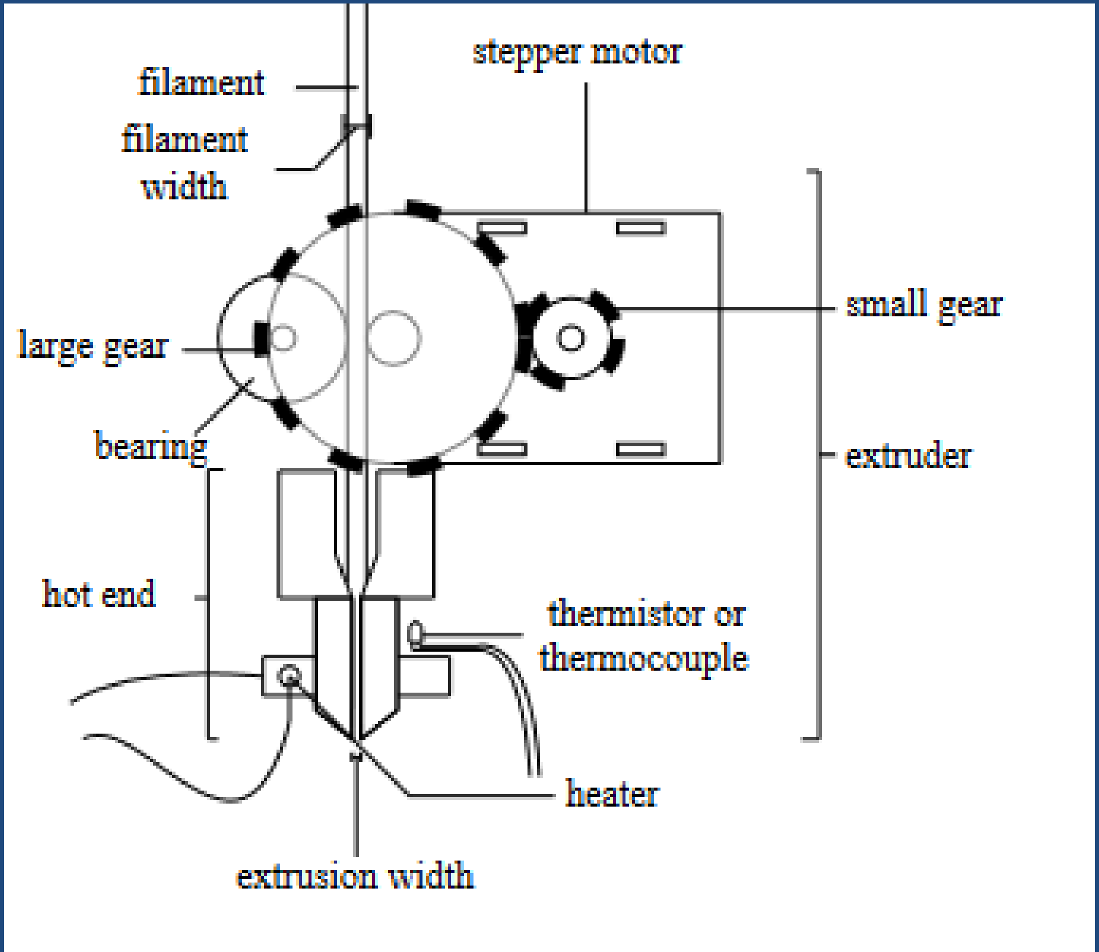
- Extrusion Deposit
- Vat Photo polymerization
- Material Jetting
- Binder Jetting
- Powder Bed Fusion
- Sheet Lamination
- Directed Energy Deposition

Extrusion Deposit



- Fused deposition modeling (FDM)
- Most commonly used
- Prototyping
- Inexpensive

Extrusion Deposit

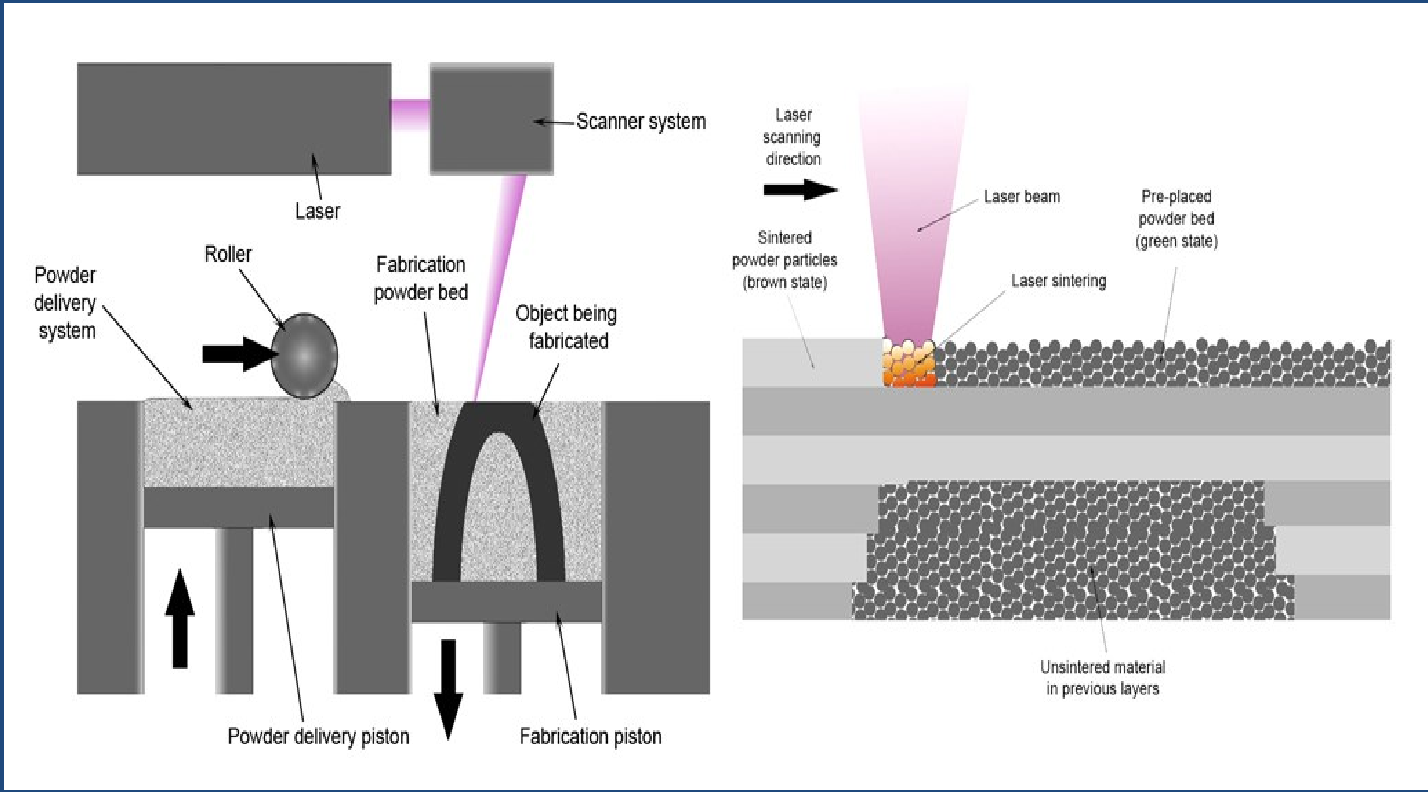


- Structure of an Extruder
- Demo of FDM

Extrusion Deposit

- Extrusion Materials
- *Acrylonitrile butadiene styrene* (ABS)
- *Polylactic acid* (PLA)
- *High-impact polystyrene* (HIPS)
- *Thermoplastic polyurethane* (TPU)
- *Aliphatic polyamides* (nylon),
- Polyether ether ketone (PEEK)
- Paste-like materials (ceramic, chocolate, …)

Power Bed Fusion

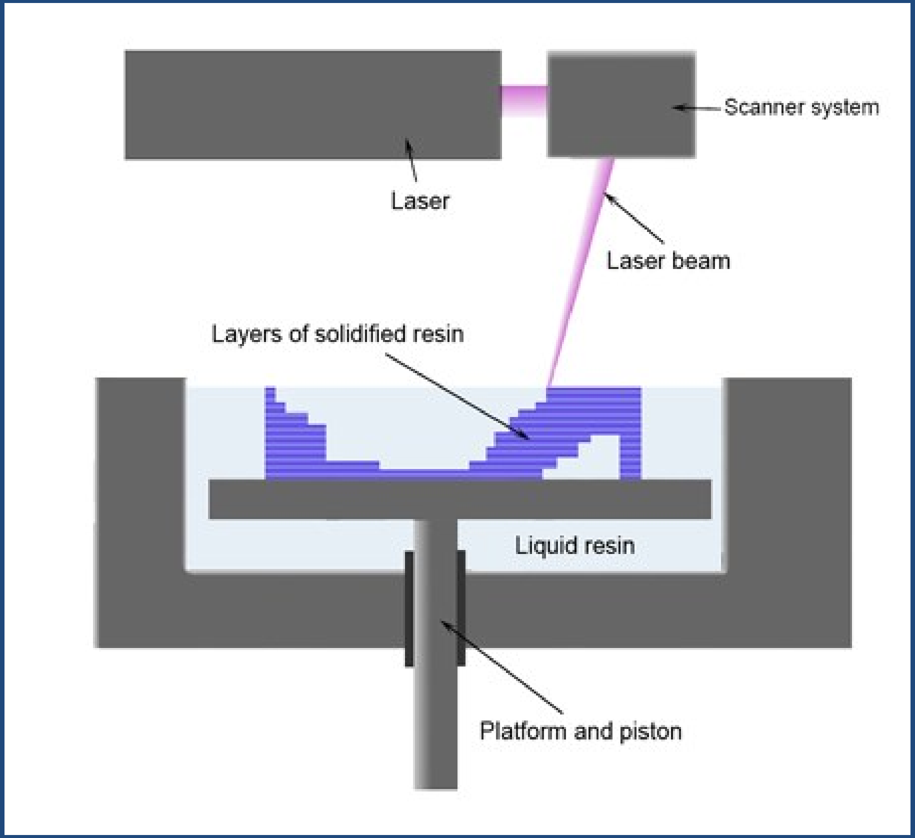


Selective laser sintering (SLS)

Powder Bed Fusion

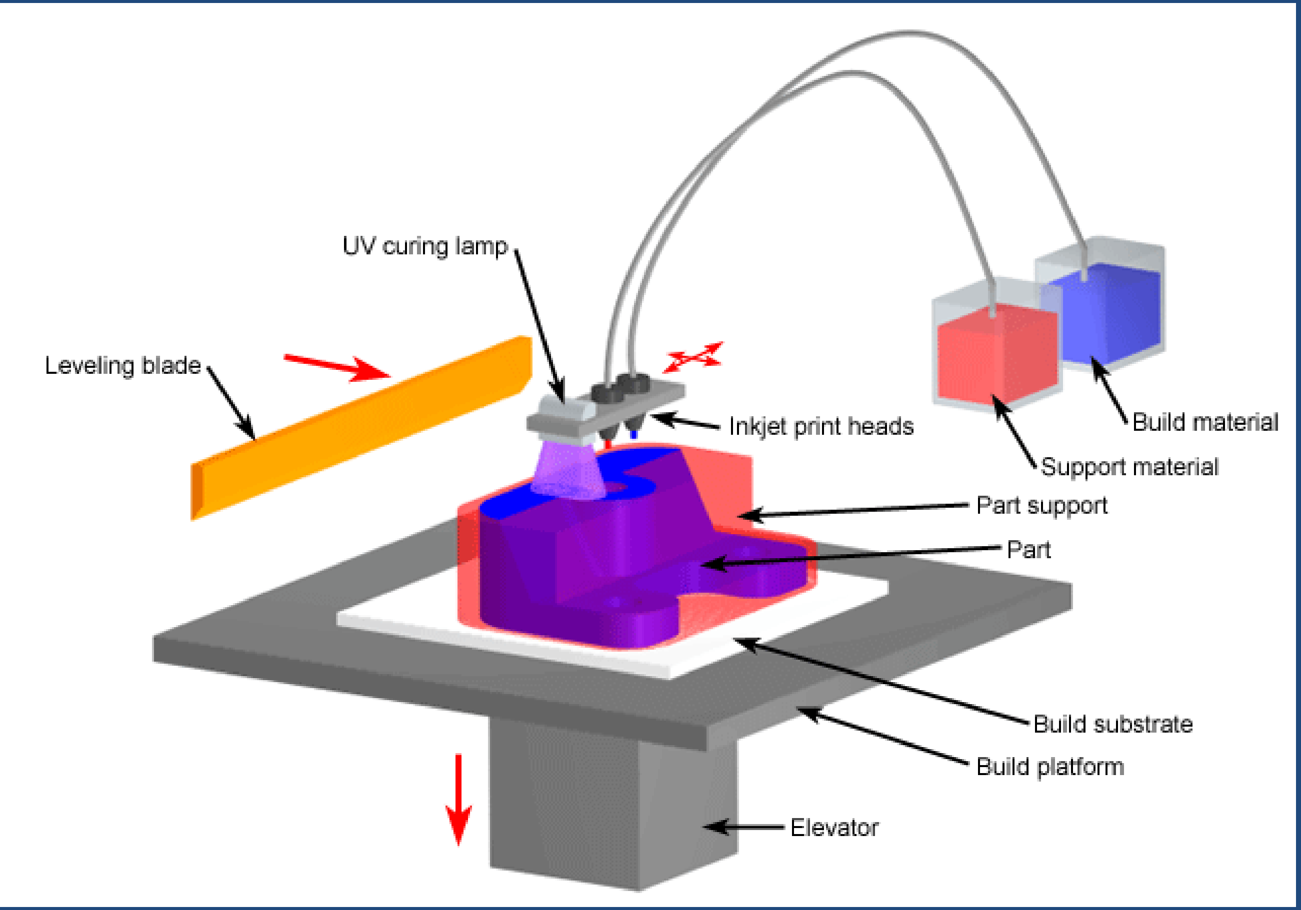
- Selective laser sintering (SLS)
- Developed in 1980s at UT Austin
- Materials: metals, polymers, nylon
- In powder form.
- Un-melted powder becomes supporting material.

Vat Photo polymerization

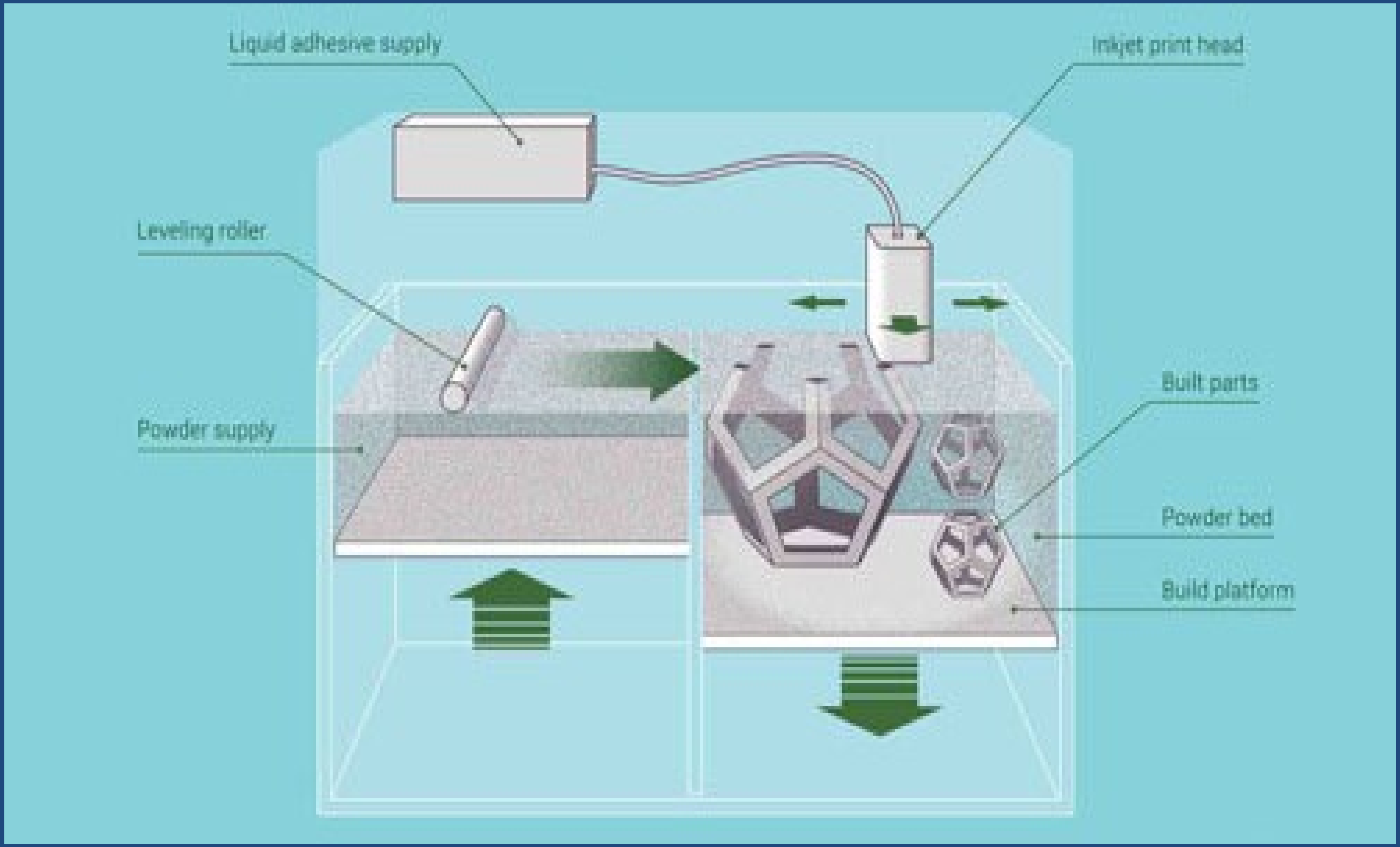


- SLA (stereolithography)
- CLIP (Continuous Liquid
- Interface Production)

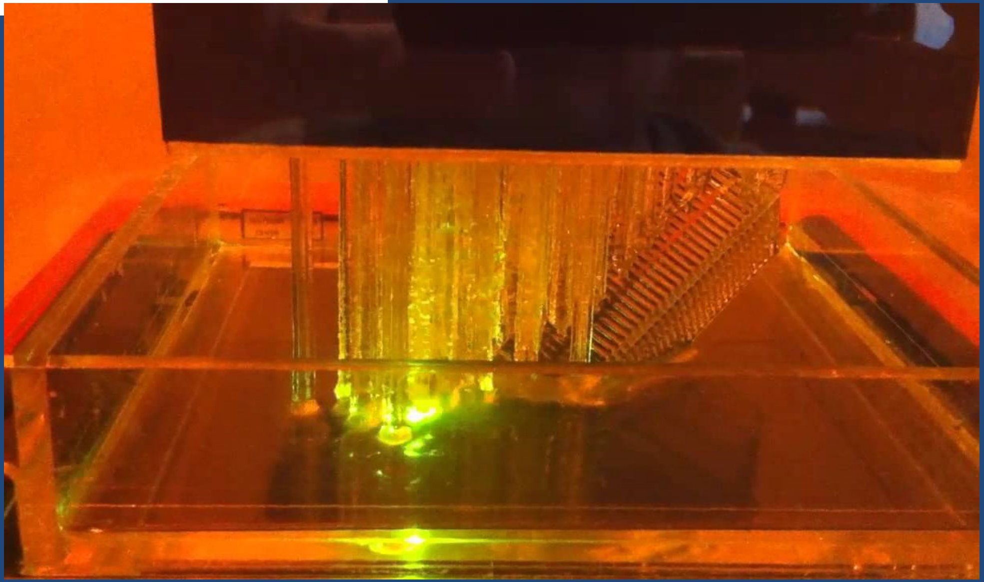
Material Jetting



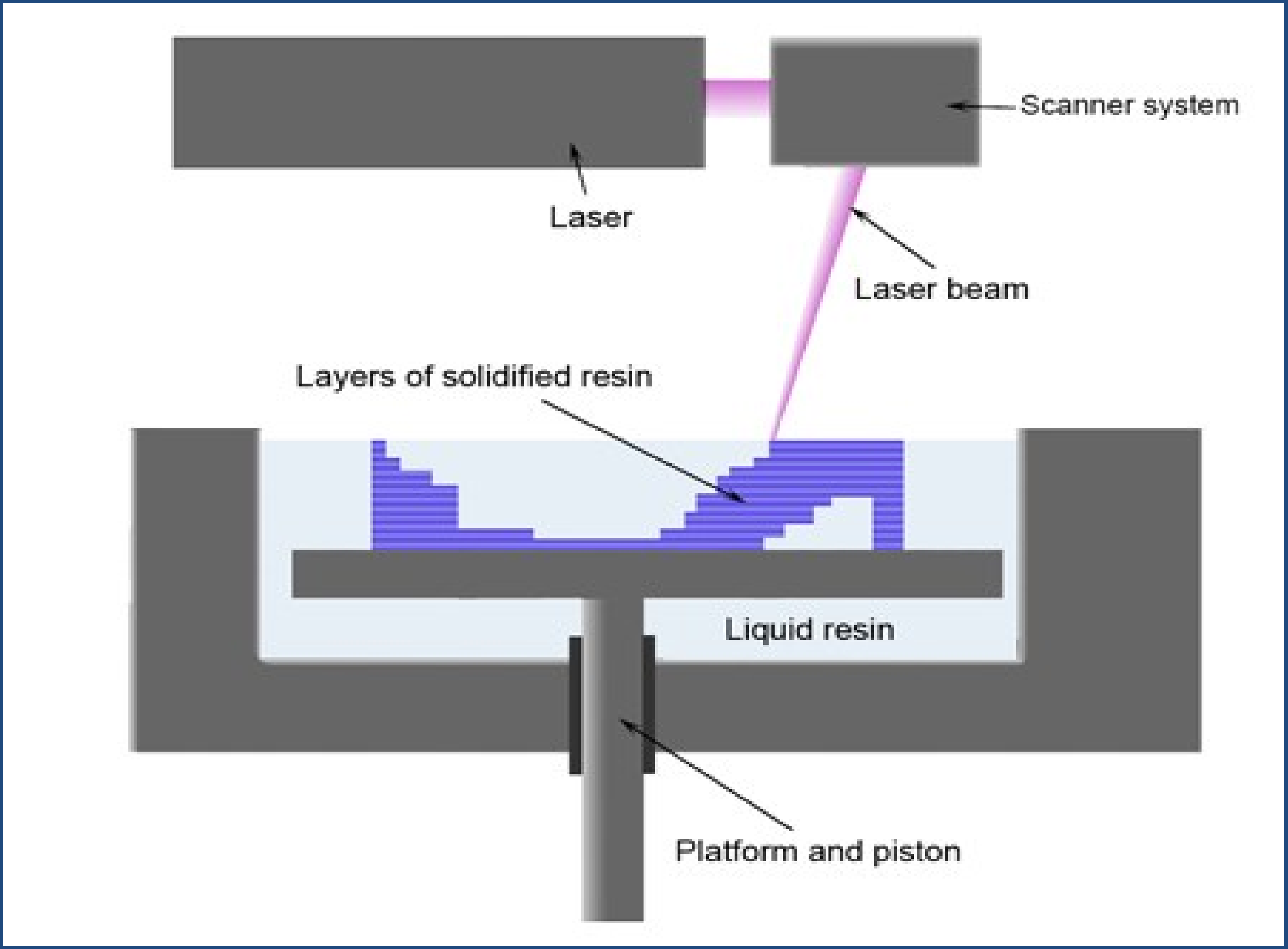
Binder Jetting



Stereolithography

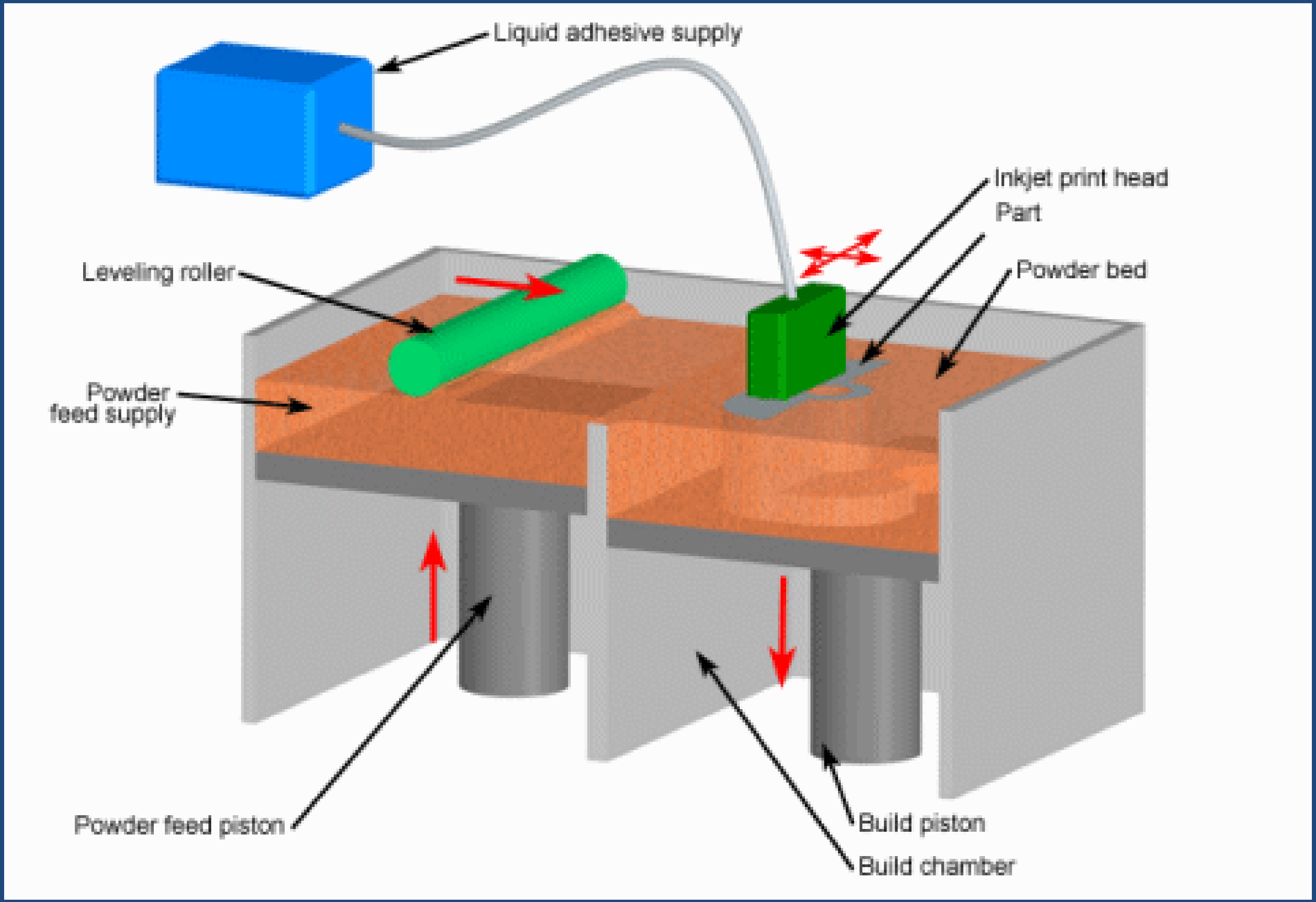


3D Printing



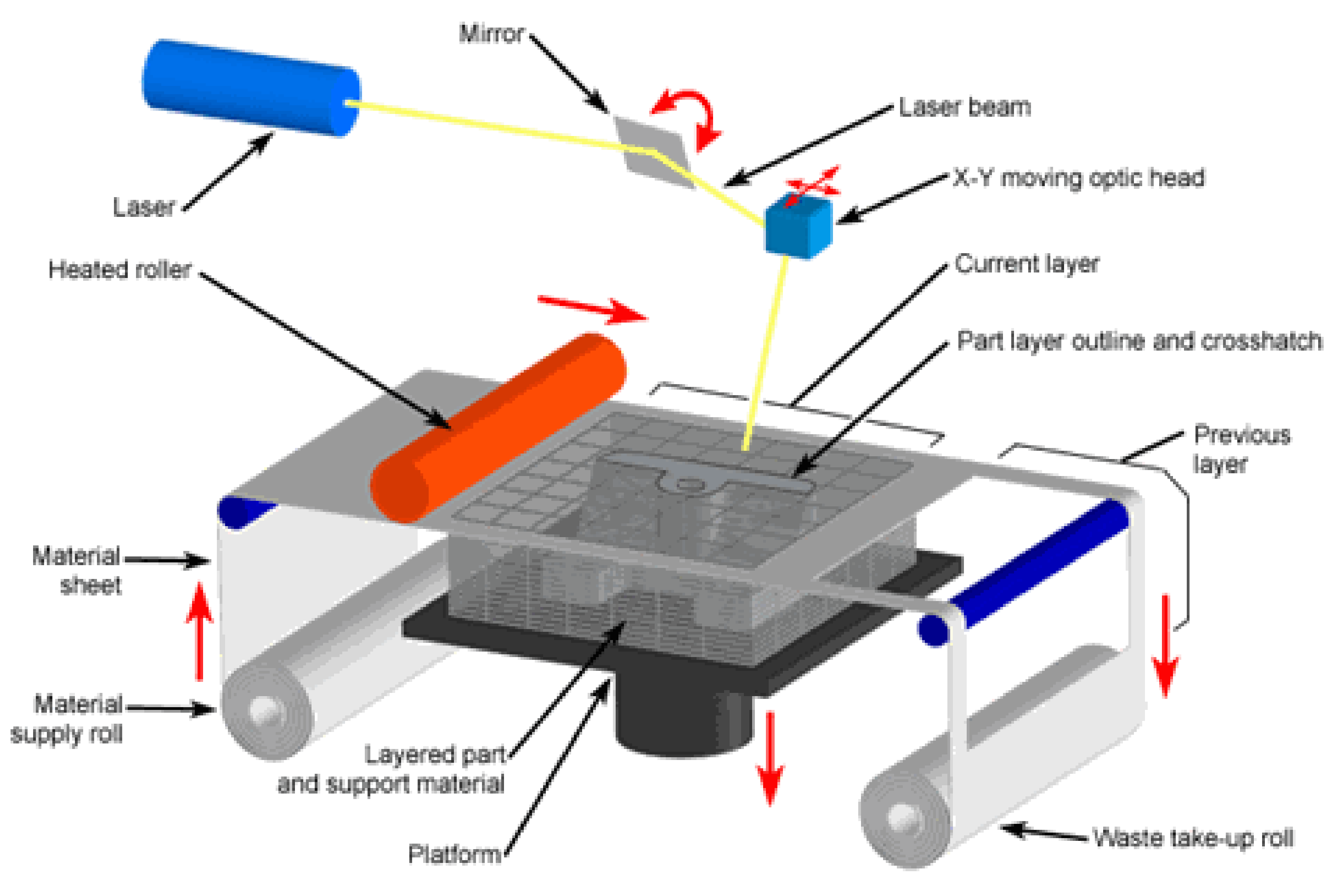
Stereolithography (SLA)

Rapid Prototyping



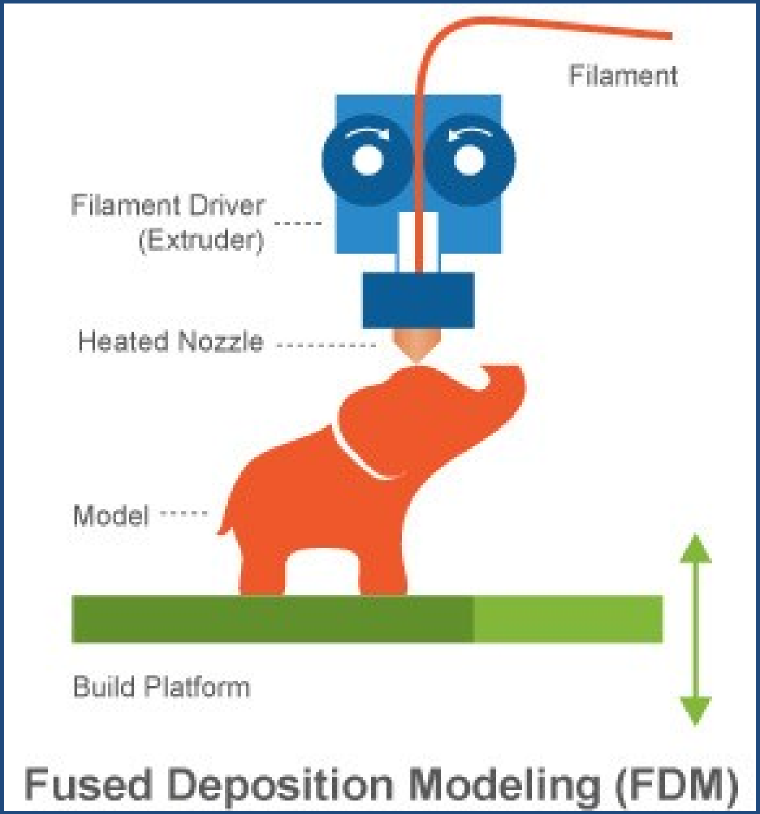
Powder Jetting

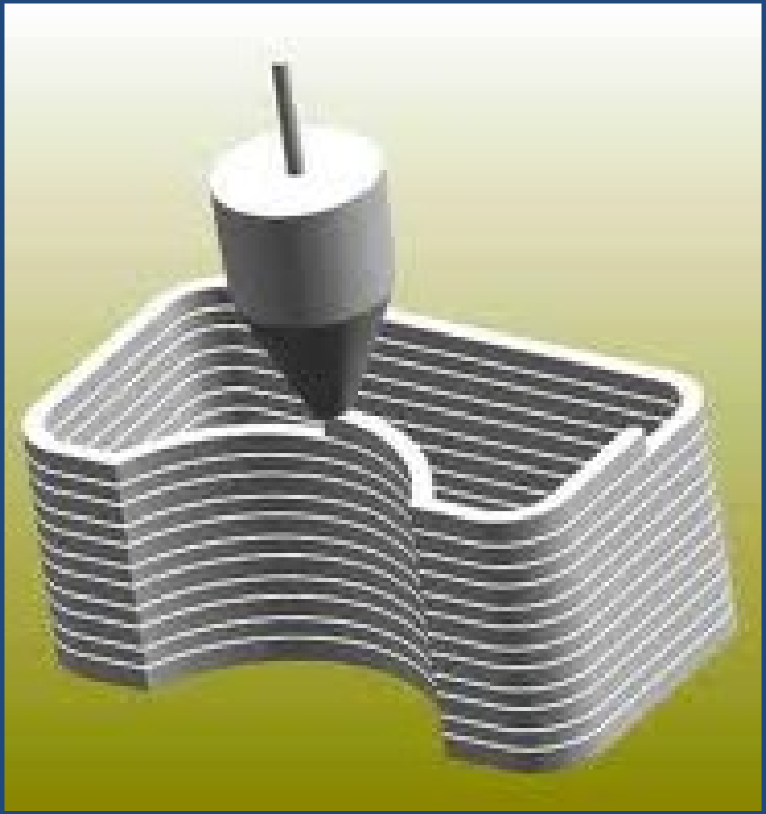
Rapid Prototyping



Laminated Object Manufacturing (LOM)

FDM


Filament
Filament Driver
(Extruder)
Heated Nozzle
Model
Build Platform
Fused Deposition Modeling (FDM)



Thank You