3D Printing: The Face of Future Fashion

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ABSTRACT: **3D printing is used for making three dimensional solid objects. The technology was first invented in the 1980s, and since that time has been used for rapid prototyping. In the last couple of years the term 3D printing has become more known and the technology has reached a broader public. Still, most people haven't even heard of the term while the technology has been in use for decades. Especially manufacturers have long used these printers in their design process to create prototypes for traditional manufacturing and research purposes. Now 3D printing has entered the world of clothing with fashion designers experimenting with 3D-printed dresses, shoes and accessories.**

Keyword: **3D Printing, Cloth manufacturing**

I. INTRODUCTION

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the entire object is created. This process leaves behind very little or no waste, and localized production reduces waste associated with transportation and shipping. 3D printed fashion requires less labor and less time for manufacturing and processing.

II. WHAT IS 3D PRINTING?

3D printing also known as additive manufacturing, turns digital 3D models into solid objects by building them up in layers. The technology was first invented in the 1980s, and since that time has been used for rapid prototyping (RP). However, in the last few years, 3D printing has additionally started to evolve into a next-generation manufacturing technology that has the potential to allow the local, on-demand production of final products or parts thereof.

Already it is possible to 3D print in a wide range of materials that include thermoplastics, thermoplastic composites, pure metals, metal alloys, ceramics and various forms of food. Right now, 3D printing as an end-use manufacturing technology is still in its infancy. But in the coming decades, and in combination with synthetic biology and nanotechnology, it has the potential to radically transform many design, production and logistics processes.

3D Systems' claim to fame started with the creation of the first commercial 3D printing machine, invented in 1989. Since the time of 3D Systems' conception, the market has expanded from strictly industrial applications to encompass more consumer-based systems, and a plethora of 3D printing companies are vying for a spot on top of creative sectors, including the ever-evolving world of fashion. 3D printing is slowly but surely changing the fashion world as we know it, from the runway to online retail. Some of today's loudest fashion statements are coming fresh out of a 3D printer.

III. HOW DOES 3D PRINTING WORK?

It all starts with making a virtual design of the object you want to create. This virtual design is for instance a CAD (Computer Aided Design) file. This CAD file is created using a 3D modeling application or with a 3D scanner (to copy an existing object). A 3D scanner can make a 3D digital copy of an object.

3D scanners

3D scanners use different technologies to generate a 3D model. Examples are: time-of-flight, structured / modulated light, volumetric scanning and many more. Recently, companies like Microsoft and Google enabled their hardware to perform 3D scanning, for example Microsoft's Kinect. In the near future digitising real objects into 3D models will become as easy as taking a picture. Future versions of smartphones will probably have integrated 3D scanners. Currently, prices of 3D scanners range from expensive professional industrial devices to $30 DIY scanners anyone can make at home.

3D modeling software

3D modeling software also comes in many forms. There's industrial grade software that costs thousands a year per license, but also free open source software, like Blender, for instance. Beginners can start with Tinkercad. Tinkercad has a free version and it works in browsers that support WebGL, for instance Google Chrome. They offer beginner lessons and has a built in option to get your object printed via various 3D printing services. When you have a 3D model, the next step is to prepare it in order to make it 3D printable.

From 3D model to 3D Printer

You will have to prepare a 3D model before it is ready to be 3D printed. This is what they call slicing. Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and needs to be done with software. Sometimes a 3D model can be sliced from within a 3D modeling software application. It is also possible that you are forced to use a certain slicing tool for a certain 3D printer. When the 3D model is sliced, you are ready to feed it to your 3D printer.

This can be done via USB, SD or Wifi. It really depends on what brand and type 3D Printer you have.

When a file is uploaded in a 3D printer, the object is ready to be 3D printed layer by layer. The 3D printer reads every slice (2D image) and creates a three dimensional object.

Processes and technologies

Not all 3D printers use the same technology. There are several ways to print and all those available are additive, differing mainly in the way layers are build to create the final object.

Some methods use melting or softening material to produce the layers. Selective laser sintering (SLS) and fused deposition modeling (FDM) are the most common technologies using this way of 3D printing. Another method is when we talk about curing a photo-reactive resin with a UV laser or another similar power source one layer at a time. The most common technology using this method is called stereolithography (SLA).

To be more precise: since 2010, the American Society for Testing and Materials(ASTM) group **"**ASTM F42 – Additive Manufacturing**"**, developed a set of standards that classify the Additive Manufacturing processes into 7 categories according to Standard Terminology for Additive Manufacturing Technologies**.** These seven processes are:

1. Vat Photopolymerisation

A 3D printer based on the Vat Photopolymerisation method has a container filled with photopolymer resin which is then hardened with UV light source.

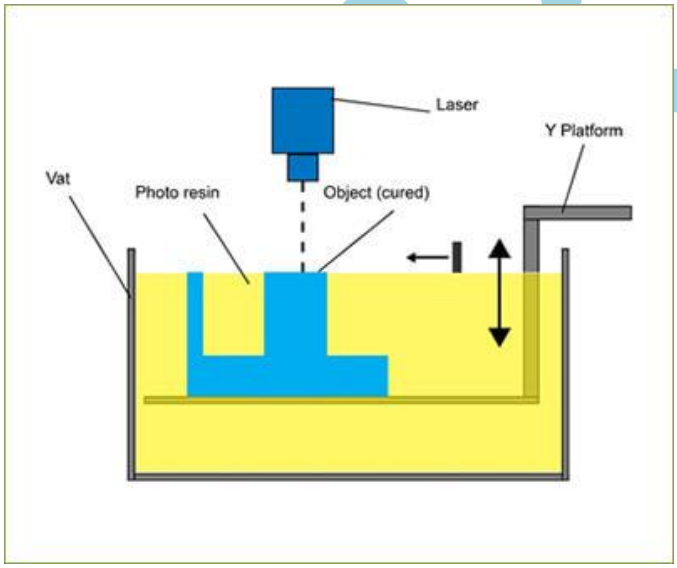


Figure 1

The most commonly used technology in this process is **Stereolithography (SLA)**. This technology employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below. This technique was invented in 1986 by Charles Hull, who also at the time founded the company, 3D Systems.

2. Material Jetting

In this process, material is applied in droplets through a small diameter nozzle, similar to the way a common inkjet paper printer works, but it is applied layer-by-layer to a build platform making a 3D object and then hardened by UV light.

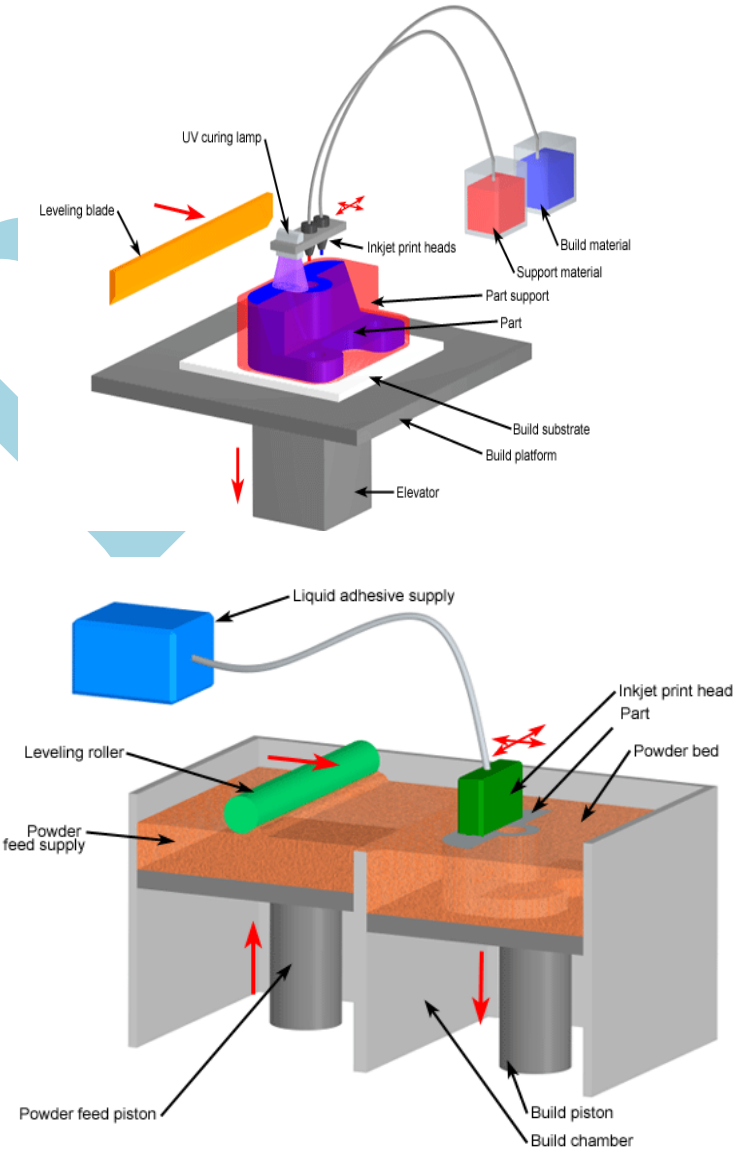
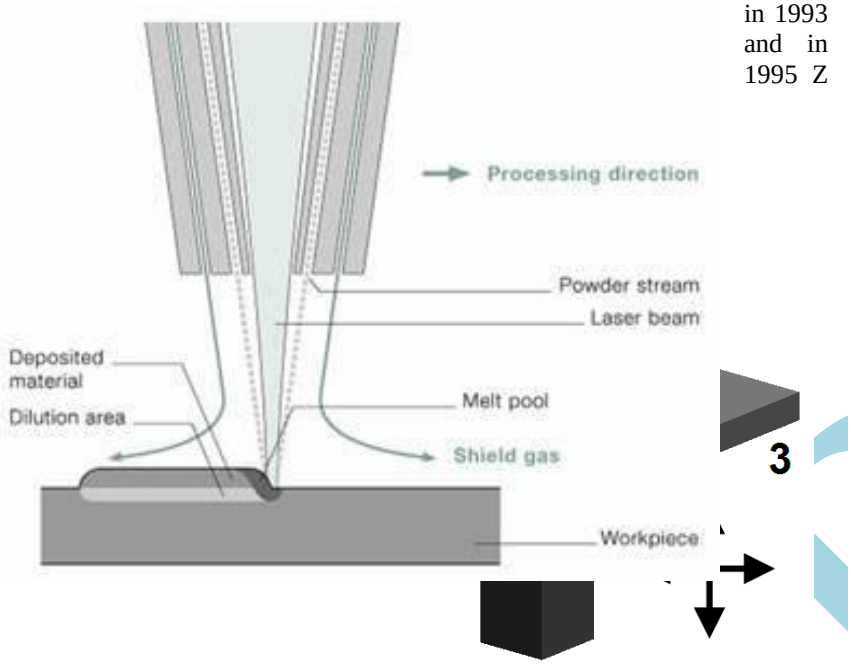


Figure 2

3. Binder Jetting

In this method two materials are used: powder base material and a liquid binder. In the build chamber, powder is spread in equal layers and binder is applied through jet nozzles that "glue" the powder particles in the shape of a programmed 3D object. The finished object is "glued together" by binder

remains in the container with the powder base material. After the print is finished, the remaining powder is cleaned off and used for 3D printing the next object. This technology was first developed at the Massachusetts Institute of Technology in 1993 and in 1995 Z



Corporation obtained an exclusive license.

4. Material Extrusion

The most commonly used technology in this process is Fused deposition modeling (FDM)

Figure 3

The FDM technology works using a plastic filament or metal wire which is unwound from a coil and supplying material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The object is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle.

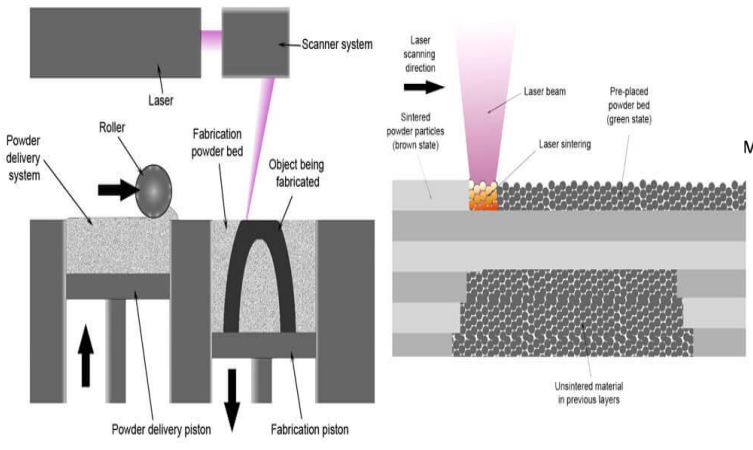


Figure 4

This technology is most widely used with two plastic filament material types: ABS (Acrylonitrile Butadiene Styrene) and PLA (Polylactic acid) but many other materials are available ranging in properties from wood filed, conductive, flexible etc.

FDM was invented by Scott Crump in the late 80's. After patenting this technology he started the company Stratasys in 1988. The software that comes with this technology automatically generates support structures if required. The machine dispenses two materials, one for the model and one for a disposable support structure.

5. Powder Bed Fusion

The most commonly used technology in this process is Selective laser sintering (SLS)

This technology uses a high power laser to fuse small particles of plastic, metal, ceramic or glass powders into a mass that has the desired three dimensional shape. The laser selectively fuses the powdered material by scanning the cross-sections (or layers) generated by the 3D modeling program on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness. Then a new layer of material is applied on top and the process is repeated until the object is completed.

All untouched powder remains as it is and becomes a support structure for the object. Therefore there is no need for any support structure which is an advantage over SLS and SLA. All unused powder can be used for the next print. SLS was developed and patented by Dr. Carl Deckard at the University of Texas in the mid-1980s.

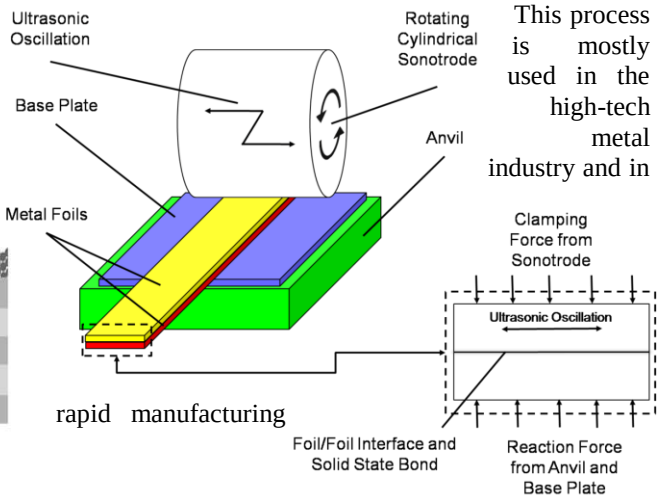
6. Sheet Lamination

Sheet lamination involves material in sheets which is bound together with external force. Sheets can be metal, paper or a form of polymer. Metal sheets are welded together by ultrasonic welding in layers and then CNC milled into a proper shape. Paper sheets can be used also, but they are glued by adhesive glue and cut in shape by precise blades. A leading company in this field is Mcor Technologies.

Simplified model of ultrasonic sheet metal 3D printing

Figure 5

7. Directed Energy Deposition



This process is mostly used in the high-tech metal industry and in rapid manufacturing

applications. The 3D printing apparatus is usually attached to a multi-axis robotic arm and consists of a nozzle that deposits metal powder or wire on a surface and an energy source (laser, electron beam or plasma arc) that melts it, forming a solid object.

IV. MATERIALS USED IN 3 D PRINTING

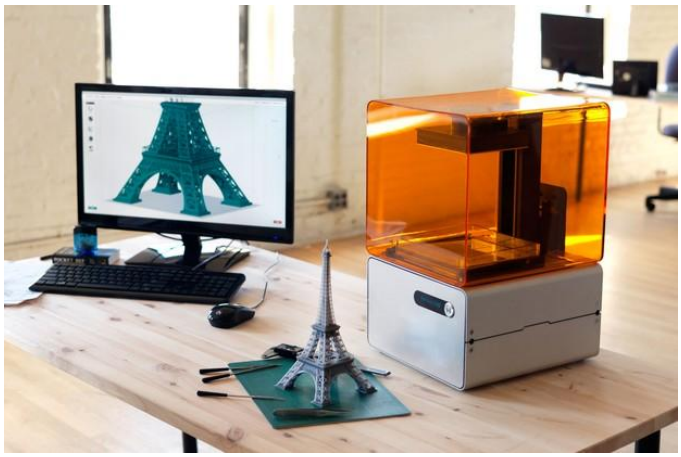
Although 3D printing materials have evolved from simple plastics to a wide range of materials like nylons, wood, salt, cement and even printing food.

V. APPLICATIONS OF 3 D PRINTING

3D printing has entered the world of clothing with fashion designers experimenting with 3D-printed bikinis, shoes, and dresses.In commercial production Nike is using 3D printing to prototype and manufacture the 2012 Vapor Laser Talon football shoe for players of American football, and New Balance is 3D manufacturing custom-fit shoes for athletes. 3D printing has come to the point where companies are

Type	Technologies	Materials
Extrusion	Fused deposition modeling (FDM) or Fused Filament Fabrication (FFF)	Thermoplastics, eutectic metals, edible materials, Rubbers, Modeling clay, Plasticine, Metal clay (including Precious Metal Clay)
	Robocasting or Direct Ink Writing (DIW)	Ceramic materials, Metal alloy, cermet, metal matrix composite,ceramic matrix composite
Light polymerized	Stereolithography (SLA)	Photopolymer
	Digital Light Processing (DLP)	Photopolymer
Powder Bed	Powder bed and inkjet head 3D printing (3DP)	Almost any metal alloy, powdered polymers, Plaster
	Electron-beam melting (EBM)	Almost any metal alloy including Titanium alloys
	Selective laser melting (SLM)	Titanium alloys, Cobalt Chrome alloys, Stainless Steel, Aluminium
	Selective heat sintering (SHS)[42]	Thermoplastic powder
	Selective laser sintering (SLS)	Thermoplastics, metal powders, ceramic powders
	Direct metal laser sintering (DMLS)	Almost any metal alloy
Laminated	Laminated object manufacturing(LOM)	Paper, metal foil, plastic film
Powder Fed	Directed Energy Deposition	Almost any metal alloy
Wire	Electron beam freeform fabrication(EBF^3)	Almost any metal alloy

printing consumer grade eyewear with on-demand custom fit and styling.



Other applications of 3D printing include rapid prototyping, architectural scale models & maquettes, healthcare (3D printed prosthetics and 3D printing with human tissue) and entertainment (e.g. film props). Other examples of 3D printing would include reconstructing fossils in paleontology, replicating ancient artifacts in archaeology, reconstructing bones and body parts in forensic pathology and reconstructing heavily damaged evidence acquired from crime scene investigations.

The true future of 3D printing lies in Bio Printing. The medical field has a lot of progress in this field, for instance the first human blood vessels and organs have already been printed. These new developments within the medical field might also be applied onto the fashion industry. If it is possible to print human cells, printing silks, cottons and other natural fibers would be the next step in 3d printing for the fashion industry.

Medical application of 3 D printing

Since the time of 3D Systems' conception, the market has expanded from strictly industrial applications to encompass more consumer-based systems. The idea behind using 3D printing in apparel is to cut out the waste of the clothing industry and to provide a system for personalized, printed polymer clothing that takes just 24 hours to produce.

We are now seeing a move towards new technology being reflected in the designs themselves as well as in the manufacturing process, in particular with the use of 3D printing technology to develop cutting-edge creations. In the past two years, these 3D printed products have been attracting a lot of attention. Iris Van Herpen unveiled her 3D printed designs at Paris Fashion Week in 2013, and a few months later Dita Von Teese made headlines by appearing in a 3D printed dress designed by Michael Schmidt and Francis Bitoni.

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