An introduction of 3D printing technology

-for general purpose

Yige

3D printing

- **Additive manufacturing approach**
- **History of additive manufacturing**
- **How does additive manufacturing work?**
- **3D printing technologies**
- **3D printing materials**
- **3D printing applications**
- **3D printing technology steps**
- **Use of software – demo - cura**

Multiple Choice(multiple) Points: 1

Setting

What are the three classes of materials?

A Polymer

B Organic

C Metal

D Ceramic

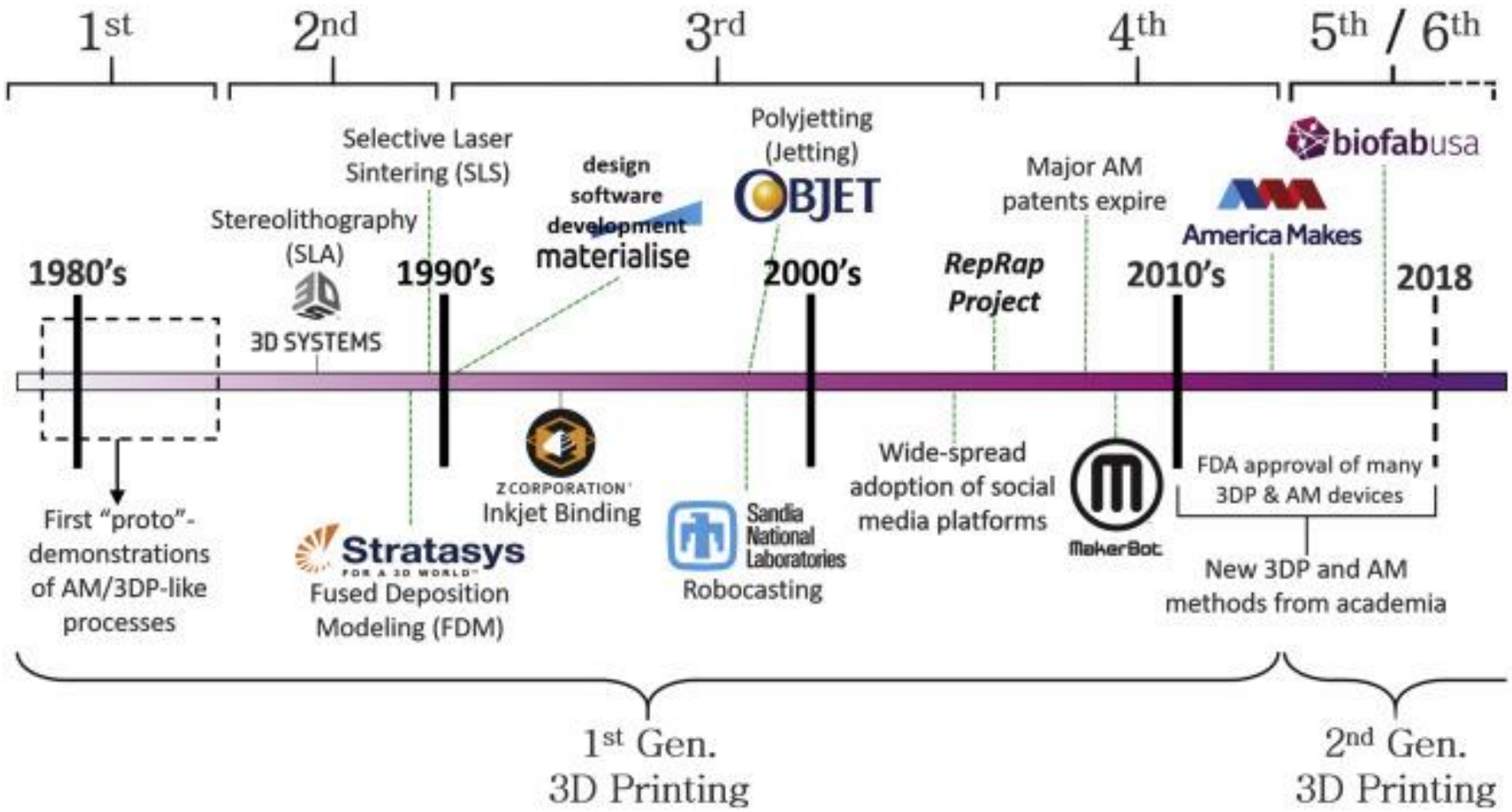
Submit

2.1 Additive manufacturing approach

Additive manufacturing (AM), also known as 3D printing, is a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems.

By using 3D printing, it is possible to produce objects of almost any shape and form.

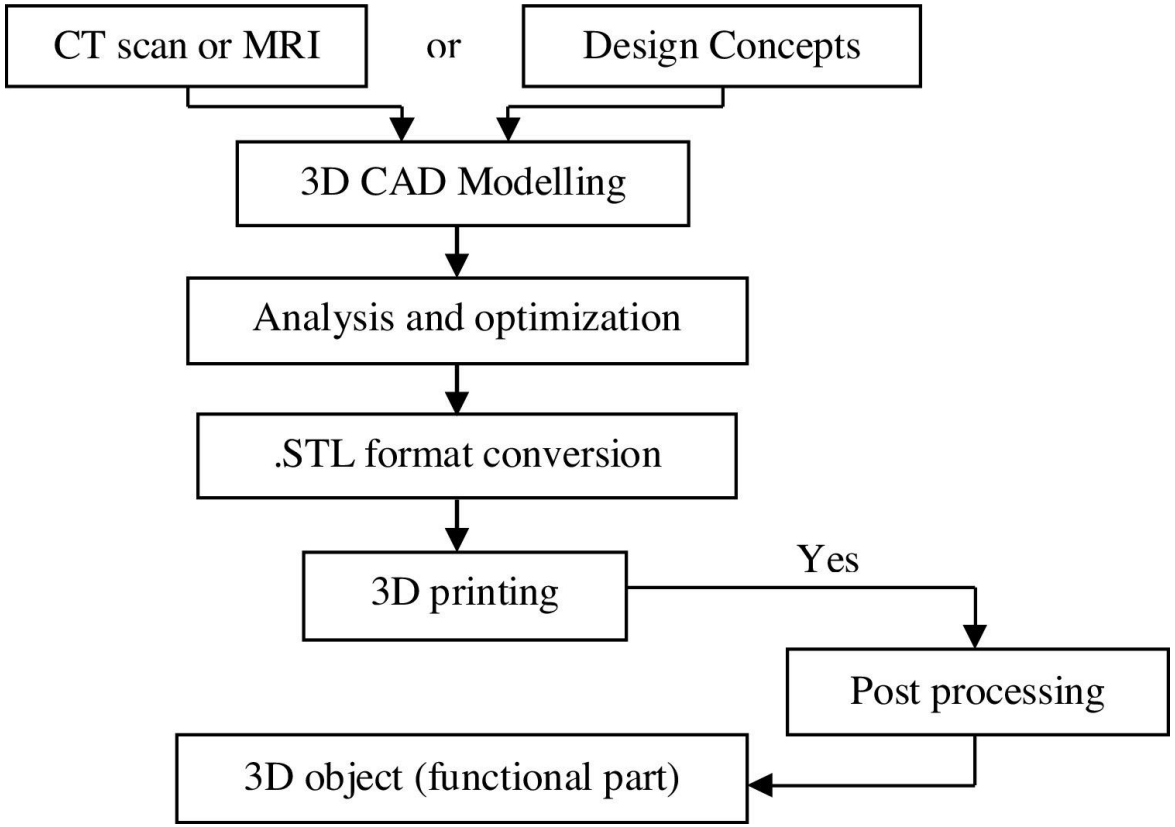
2.2 History of Additive manufacturing



Summarized timeline with major eras and select events in the history of additive manufacturing (AM) and 3D printing (3DP).

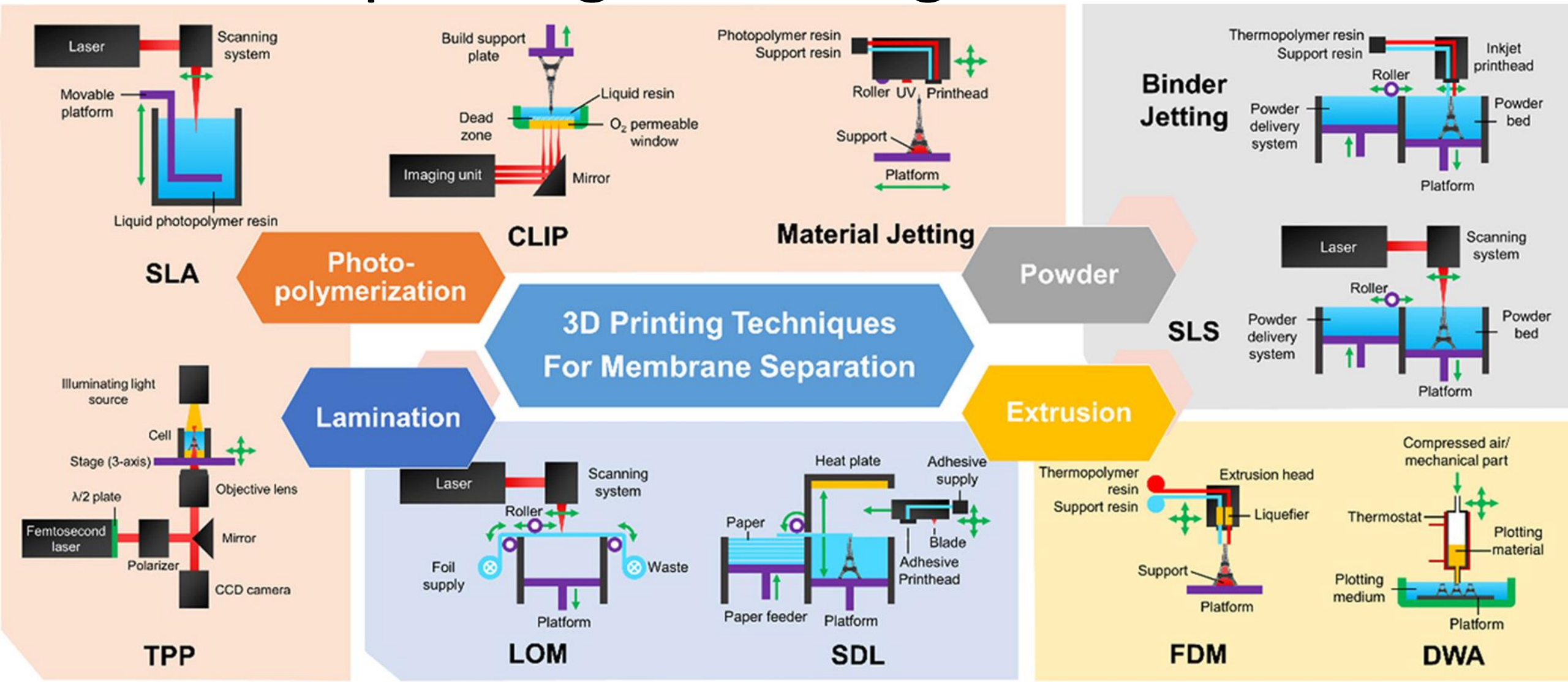
3D Printing in Orthopaedic Surgery.https://doi.org/10.1016/B978-0-3

2.3 How does additive manufacturing work?



Journal of Manufacturing Processes 25 (2017) 185-200

2.4 3D printing technologies



Journal of Membrane Science 523 (2017) 596-613

Various 3D printing technologies:

https://www.youtube.com/watch?v=iwg_rrjV7i4-

Multiple Choice(single) Points: 1

Setting

What is the most used 3D printing technology?

STL

FDM

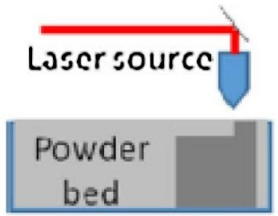
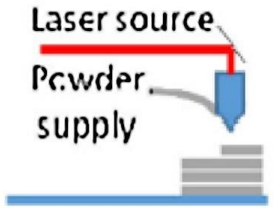
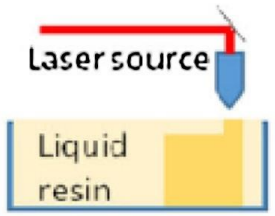
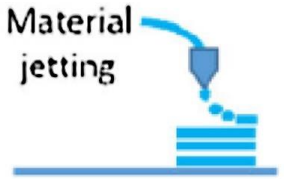
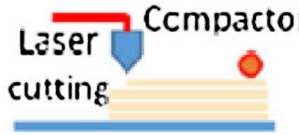
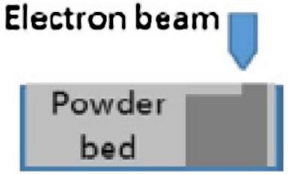
DLD

Submit

2.5 3D printing materials

- **Thermoplastics**
- **Metals**
- **Ceramics**
- **Biochemicals**

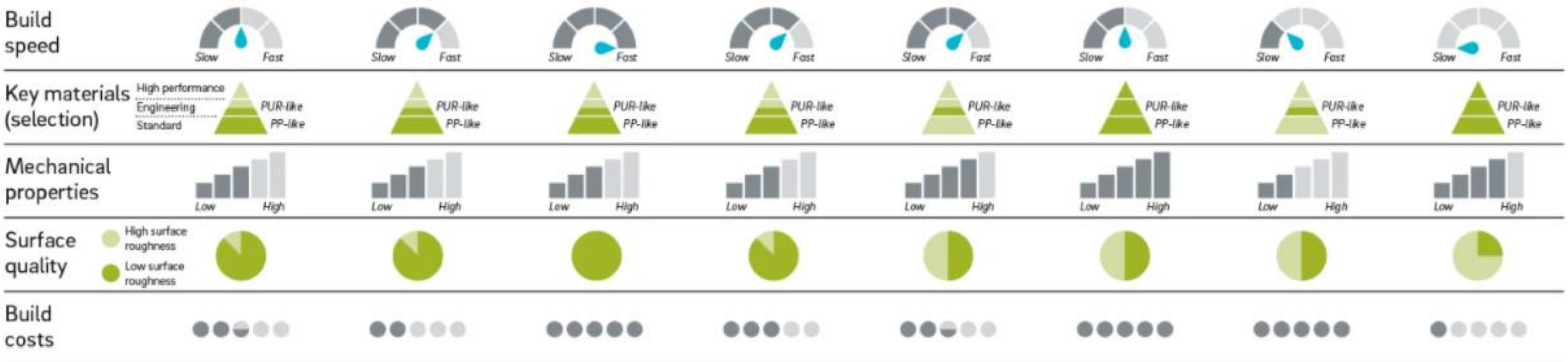
Additive Manufacturing (AM) Processes

Process	Laser Based AM Processes			Extrusion Thermal	Material Jetting	Material Adhesion	Electron Beam
	Laser Melting		*Laser Polymerization*				
Process Schematic							
Name Material	SLS	DMD	SLA	FDM	3DP	LOM	EBM
	SLM	LENS	SGC	Robocasting	IJP	SFP	
	DMLS	SLC	LTP		MJM		
		LPD	BIS		BPM		
			HIS		Thermojet		
Bulk Material Type		Powder	Liquid	Solid			

Journal of Manufacturing Processes 25 (2017) 185-200

Polymer AM technology characteristics overview

	RESIN BASED				POWDER BASED			FILAMENT
	Vat Photopolymerization			Material Jetting	Powder Bed Fusion		Binder Jetting	Extrusion
	SLA Stereo-lithography ↓ Cured with laser	**DLP** Digital Light Processing ↓ Cured with projector	**CDLP** Continuous Digital Light Processing ↓ Cured with LED and oxygen	**MJ** Material Jetting ↓ Cured with UV light	**MJF** Multi Jet Fusion ↓ Fused with agent and energy	**SLS** Selective Laser Sintering ↓ Fused with laser	**BJ** Binder Jetting ↓ Joined with bonding agent	**FDM** Fused Deposition Modeling ↓ Extrusion through nozzle
Build principle	Cured by laser beam	Cured by light from DLP projector	Continuous curing of photopolymer by light from DLP projector	Dispersion of photopolymer by printhead + exposure	Dispersion of fusing agent by printhead + heating	Thermal energy from laser sinters regions of a powder bed	Deposition of (colored) glue on polymer powder	Deposition of molten material through nozzle



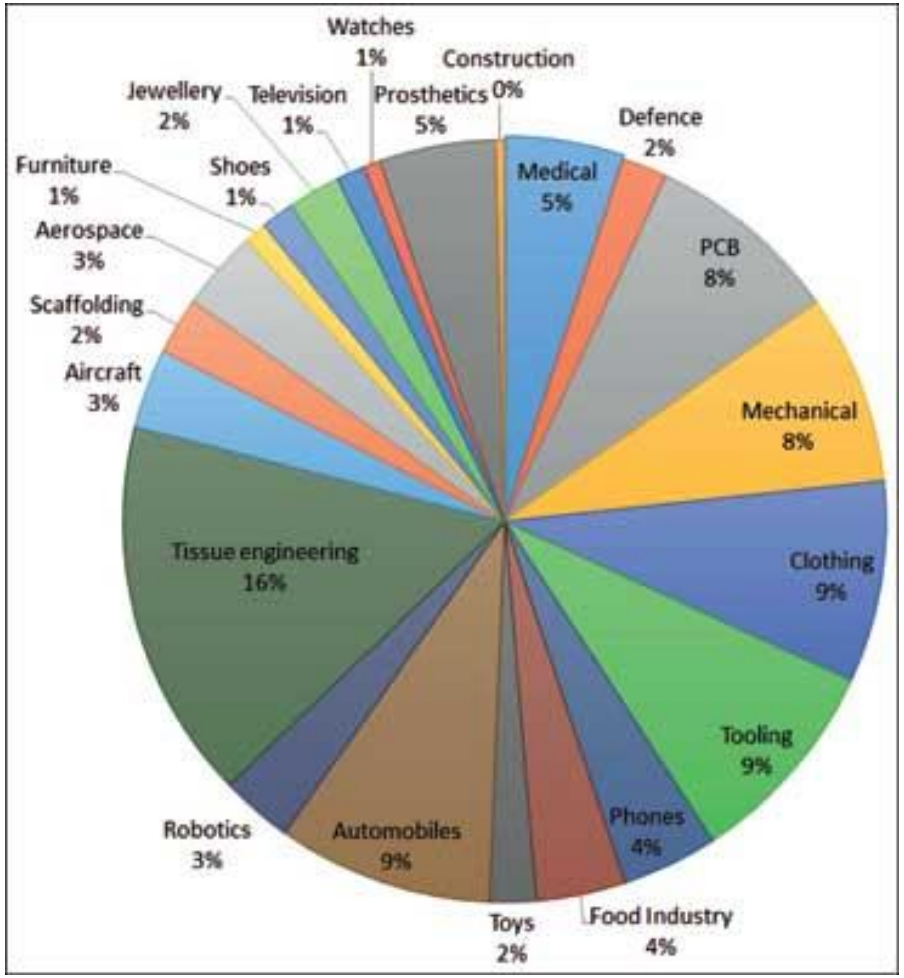
Source Roland Berger

Roland Berger

2.6 3D printing advantages

- Complexity and freedom of design
- Customization and personalization
- No need for tools
- Speed and costs saving
- Faster and less risky route to market
- Less waste, sustainable, environmentally friendly

2.7 3D printing application



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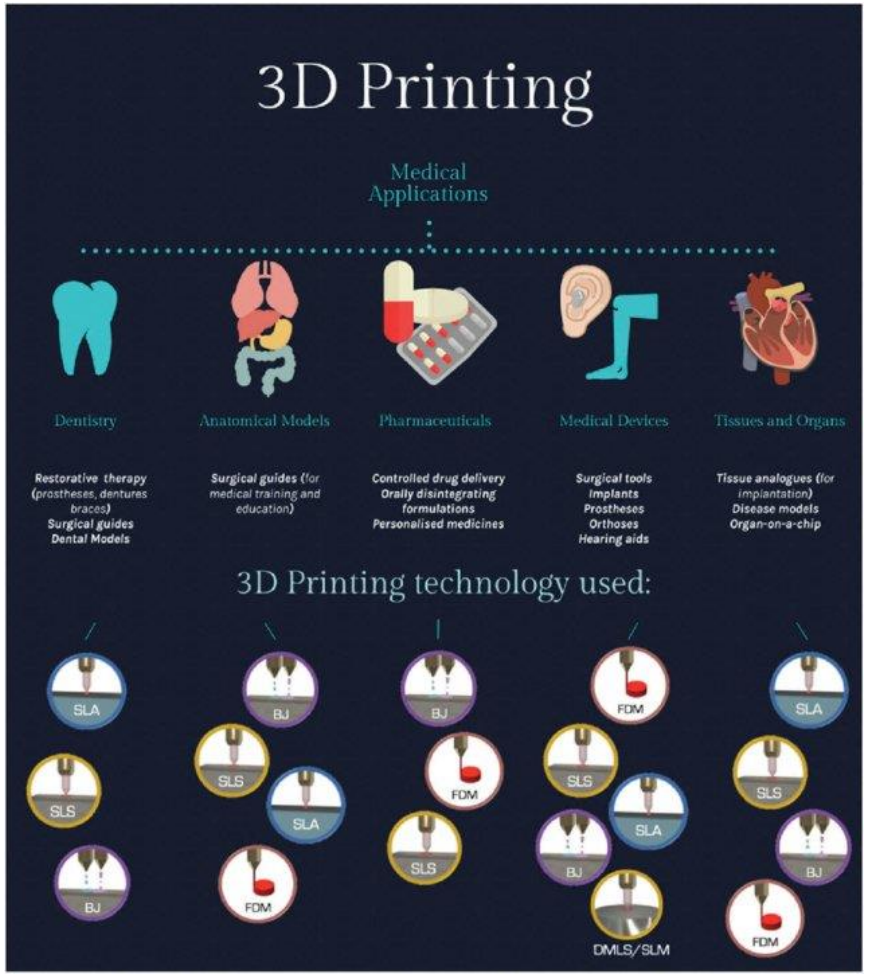


https://doi.org/10.1080/17425247.2019.1660318

2.7 3D printing application

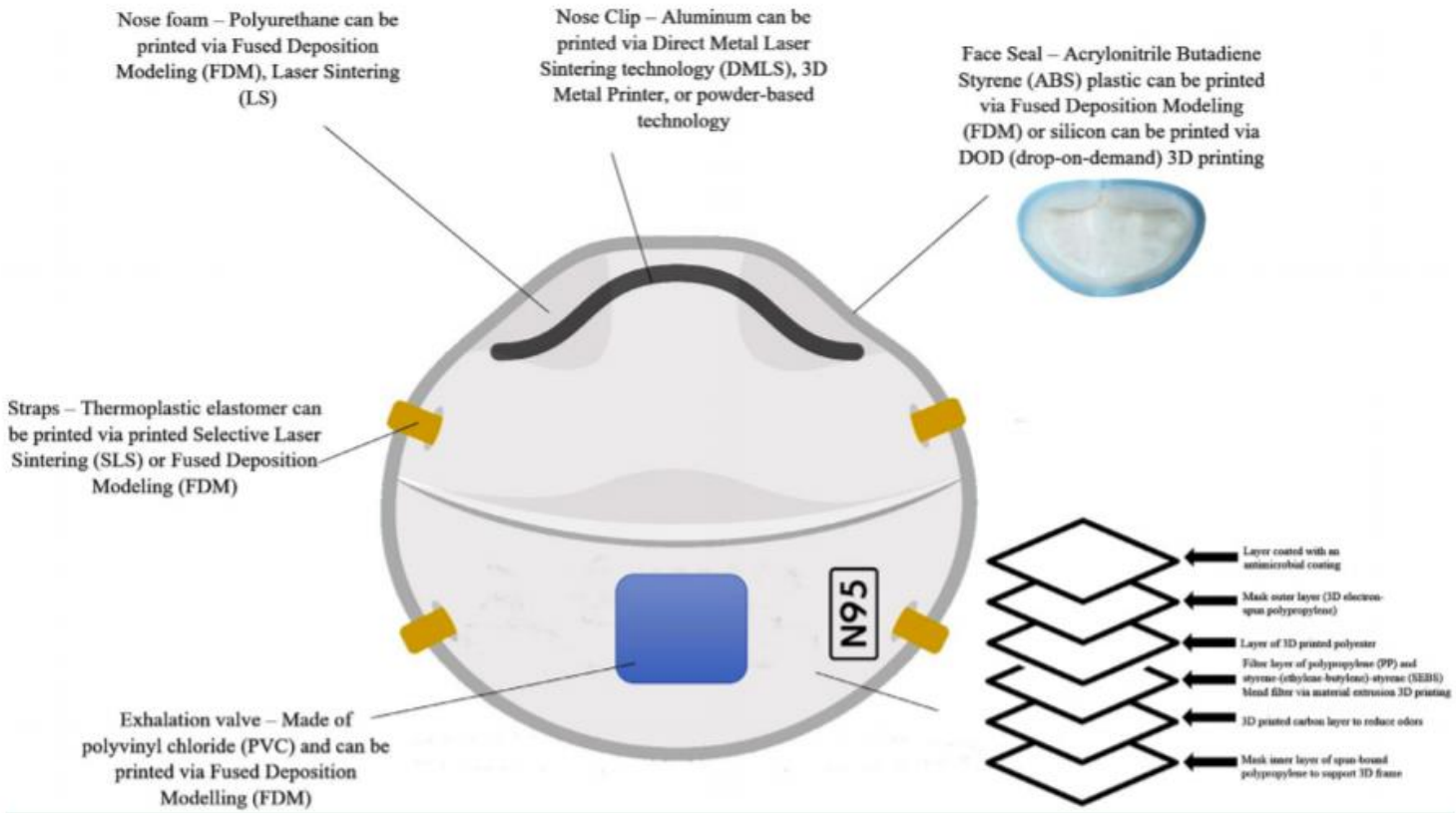
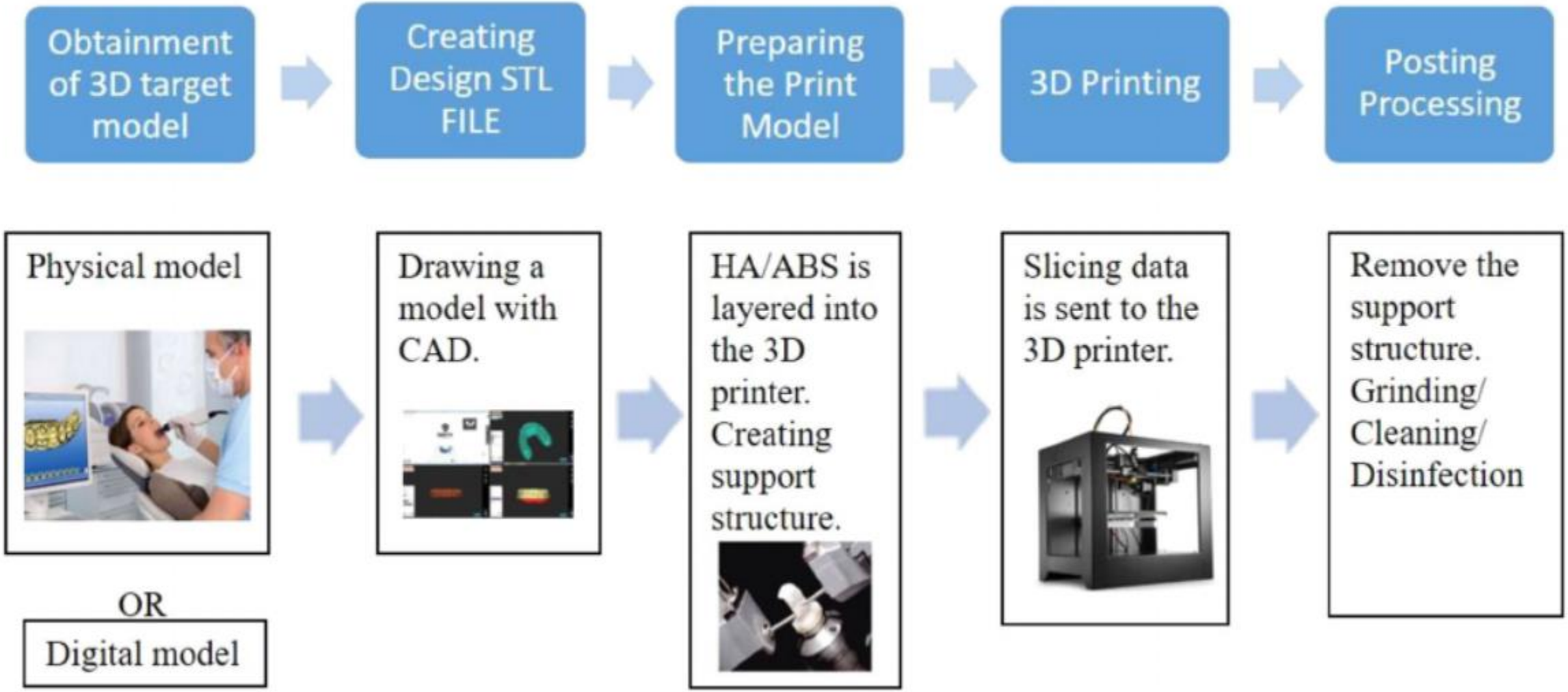


Figure 1 A potential N95 three-dimensional (3D) printed mask prototype. The biomaterials displayed in this image have been fully characterized in the medical literature, with the same material composition of N95 masks.[3-6] The mask includes several layers thereby ensuring effective filtration of viral particles.

The American Journal of Medicine, Vol 133, No 7, July 2020

2.8 3D printing technology steps



Adv. Eng. Mater. 2019, 21, 1801013

2.8.1 CAD

The first step in the additive manufacturing process is producing a digital model. For this purpose Computer Aided Design (CAD) modeling is used.

There are many CAD programs that use different modeling principles, capabilities and pricing policy. For example Solidworks, Autodesk Fusion 360, SketchUp could be used.

Reverse engineering can also be used to generate a digital model via 3D scanning.

2.8.2 Model in STL format

In this step of additive manufacturing (AM) process a CAD model is converted into a STL (stereolithography) file that is acceptable by AM Machines.

It is also possible to select a STL model from online repositories like Pinshape, GrabCAD etc. Some of these repositories offer models for free, some are charged.

2.8.3 STL model analysis and repair

In this step it is required to repair any errors within the STL file. Typical errors could be like missing triangles, non connected edges or inverted normals where the “wrong side” of a triangle facet is identified as the interior of the part.

There are software for STL model manipulations, for example Meshlab, 3DPrintCloud, Netfabb etc.

If there are no errors, then some object corrections like sizing, density, geometry changes could be made.

A proper orientation of the 3D model also could be set up.

Once a STL file has been generated it is imported into a slicer program which converts it into G-code. G-code is a numerical control (NC) programming language, used in computer-aided manufacturing (CAM) to control automated machine tools like 3D printers.

2.8.4 Setting up device

In this step device should be prepared for printing. This process requires proper printer setup and control, cleaning from previous build and loading print material. A routine check of all critical build settings and process controls is also necessary.

When hardware is ready, build file could be uploaded to the machine.

2.8.5 Printing

The whole printing procedure is mainly automatic. Depending on the size of a thing, machine and materials employed, the procedure might take several hours or even days. There is a need to check occasionally if there are no errors.

2.8.6 Removal of Prints

In most cases of non industrial 3D Printing removal of the finished print is a simple task: separating the printed part from the print bed.

2.8.7 Post processing

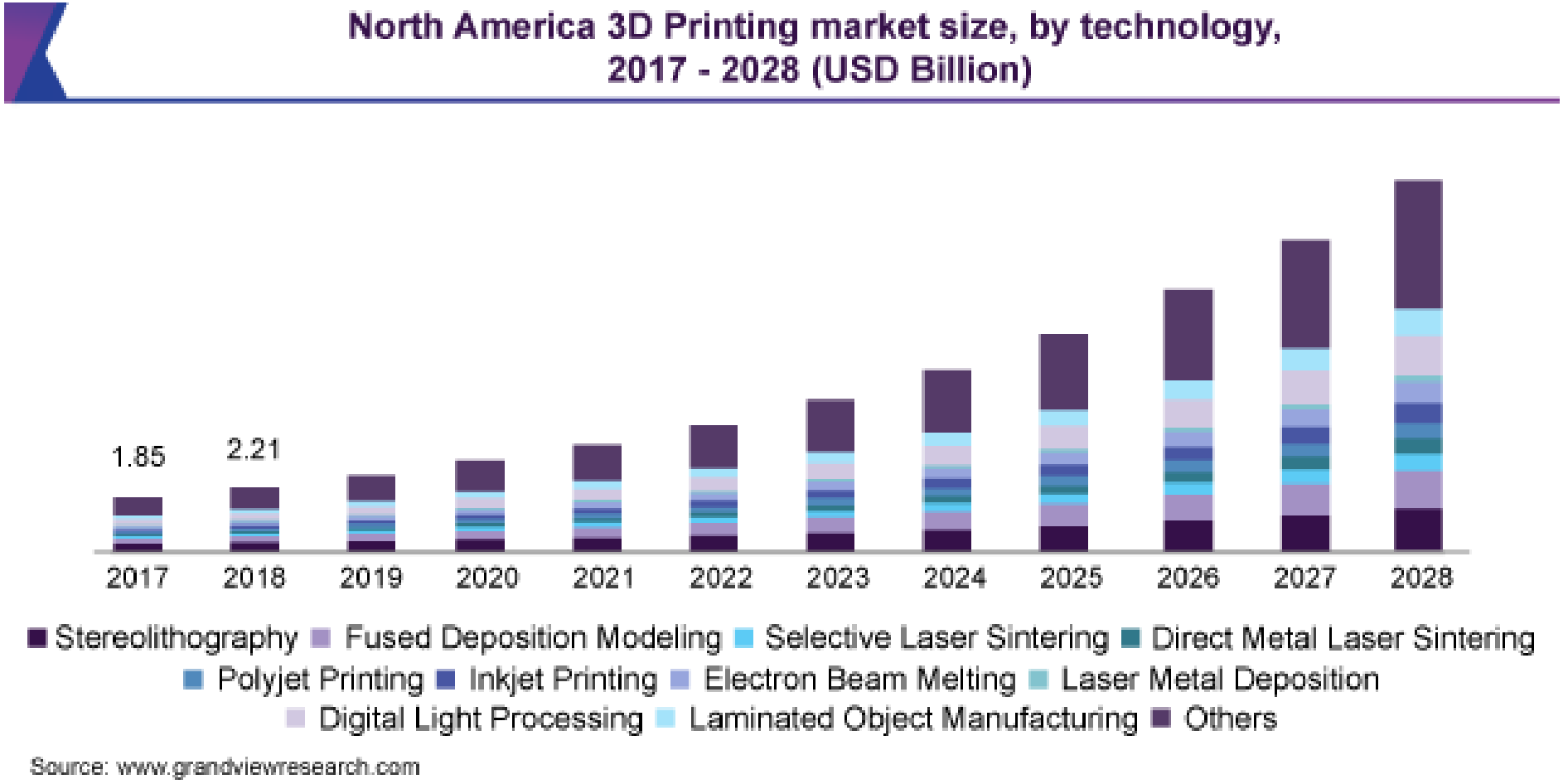
Post processing may vary greatly depending on printing technology and materials used. For example a print made with SLA must be cured under UV, while print made with FDM can be handled right away.

Post processing the final product may include high pressure air cleaning, polishing, colouring and other actions to prepare for final use.

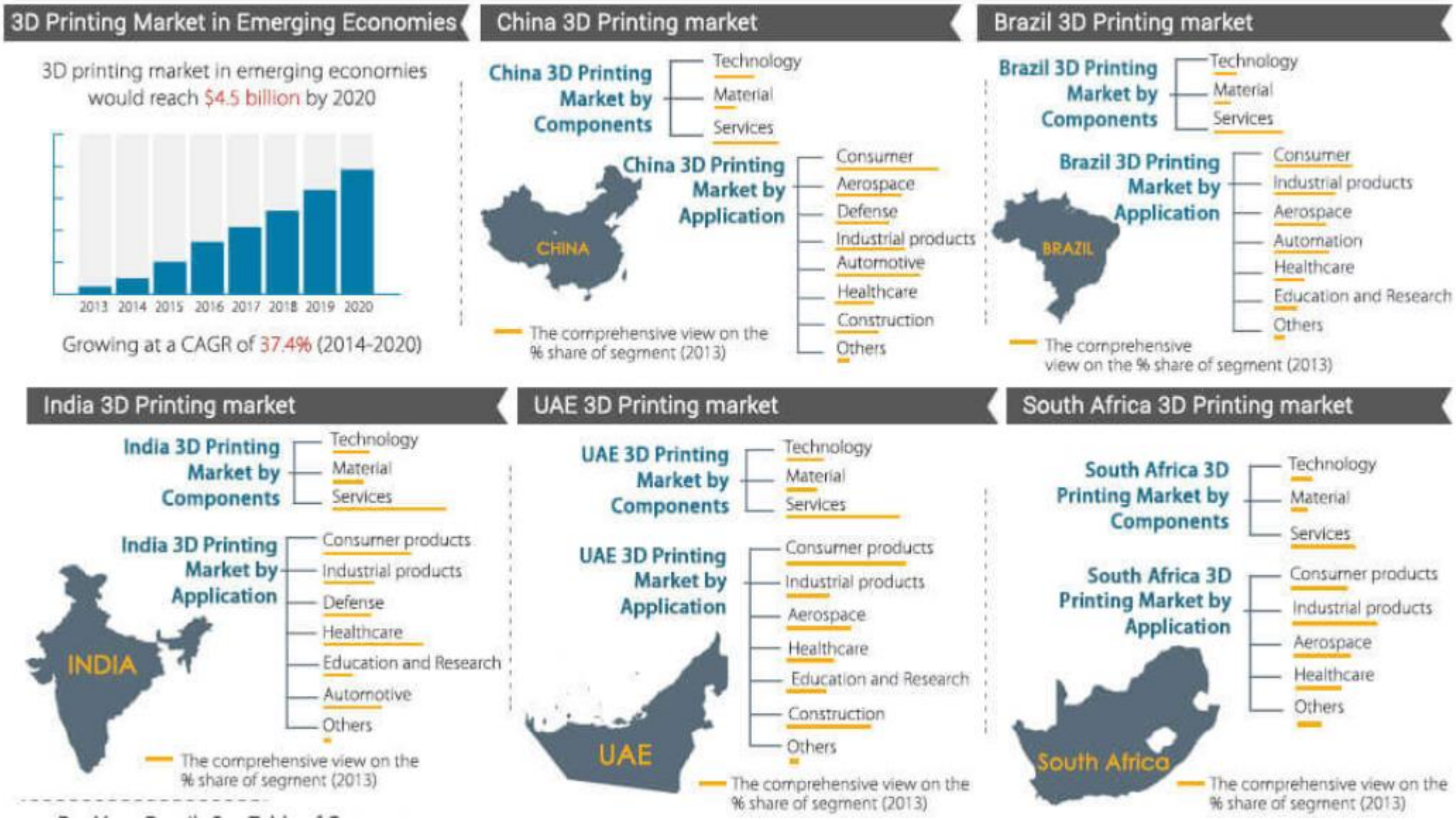
2.8.8 Use of software

Cure - demo

What does this/class mean for audience?



What does this/class mean for audience?



OpenFlexure Microscope

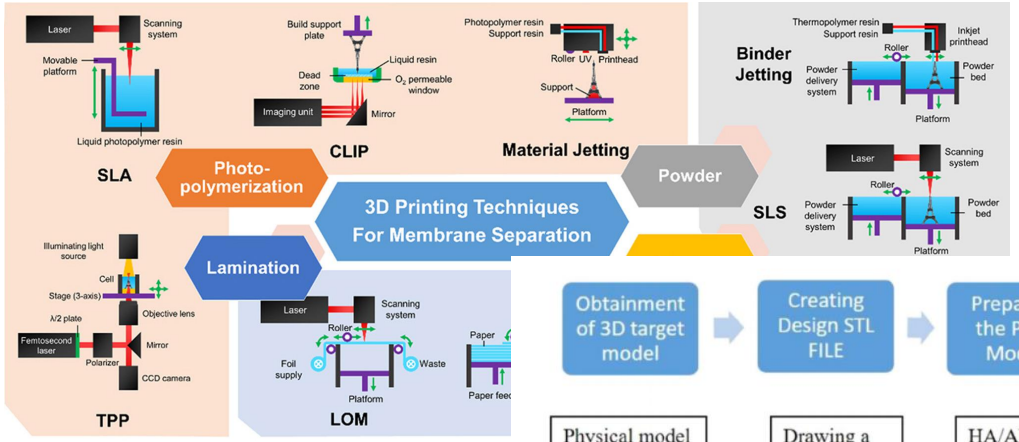
Build a Microscope

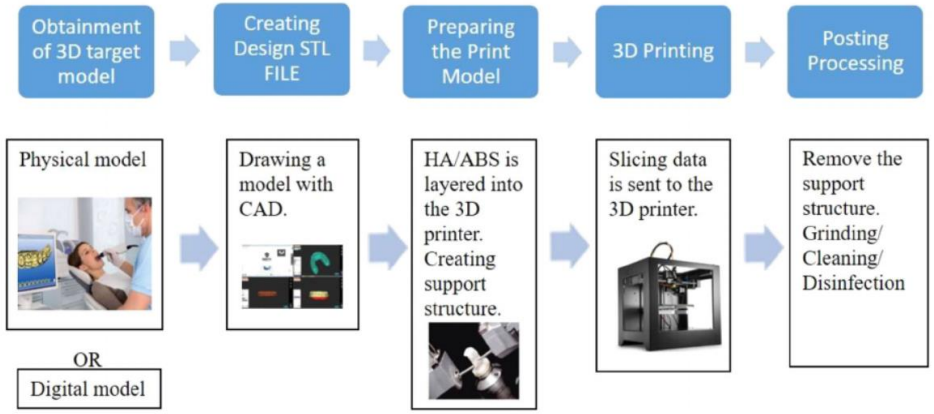
Install the Software

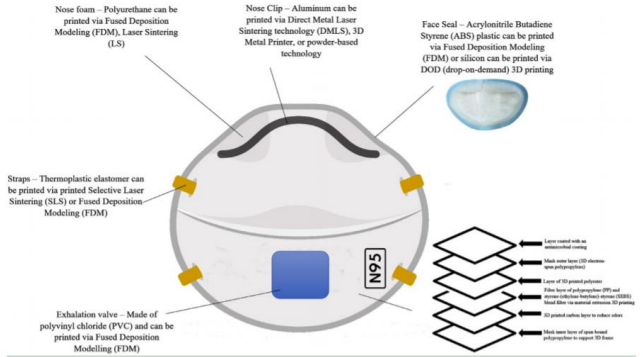
Use your Microscope

Review :

Technology
Materials
Application
Demo
Possibilities







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