www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

Additve Manufacturing

Thinking about innovation

IPHC
Institut Pluridisciplinaire Hubert Curien
STRASBOURG
http://www.iphc.cnrs.fr/

2- main additive manufacturing technics in use

processes, machine manufacturers, partners, …

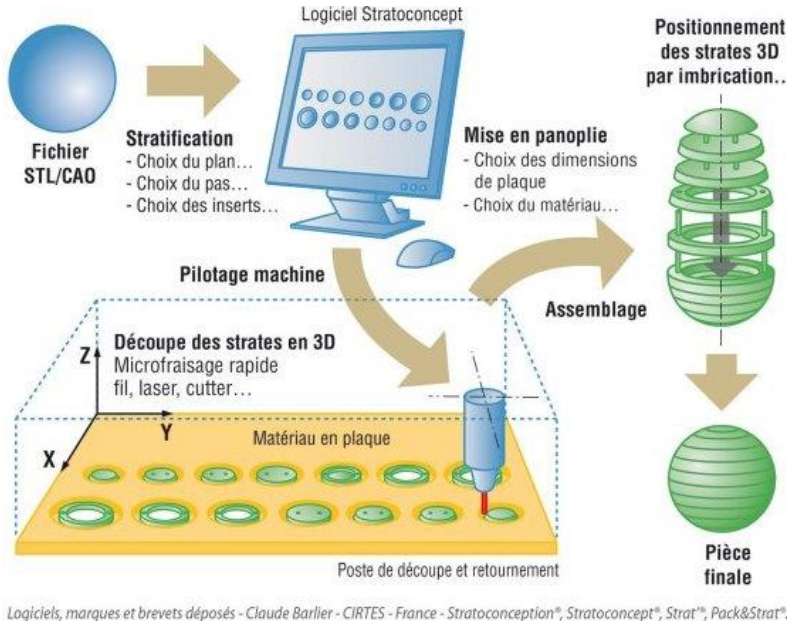
ESIPAP European School of Instrumentation in Particle and Astroparticle Physics

2- Manufacturing techniques at the service of the additive manufacturing

Stratoconception (hybrid principle : stack of machined plates or cutted sheets : glued, welded or screwed together)

Stratoconception original patent

Image Source : http://www.freepatentsonline.com/6745446.html

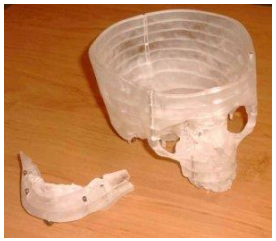


2- Manufacturing techniques at the service of the additive manufacturing

Stratoconception (hybrid principle : stack of machined plates or cutted sheets : glued, welded or screwed together)

cooling circuit on injection mould

Woods model



PMMA model

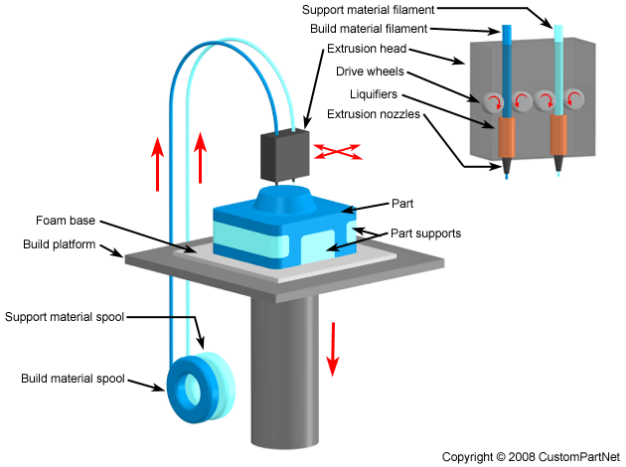
stacking of cut cardboard sheets

packaging adaptation

Image Source : http://www.freepatentsonline.com/6745446.html

Fused Deposition Modeling at CEMES laboratory (CNRS, Toulouse)

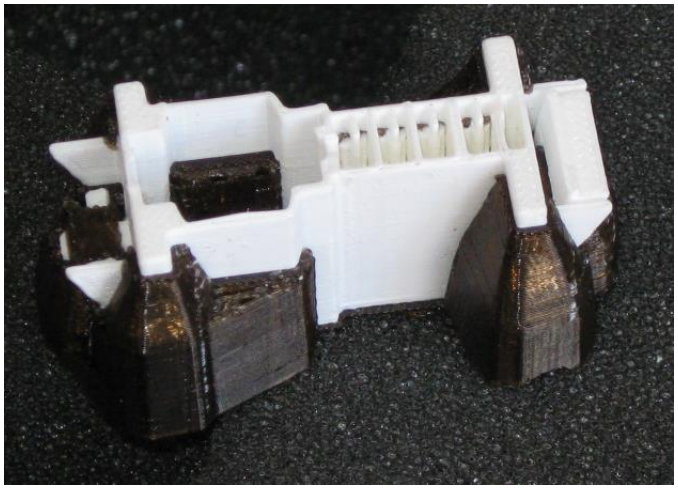
machines DIMENSION and Stratoconcept (manufacturer : STRATASYS)



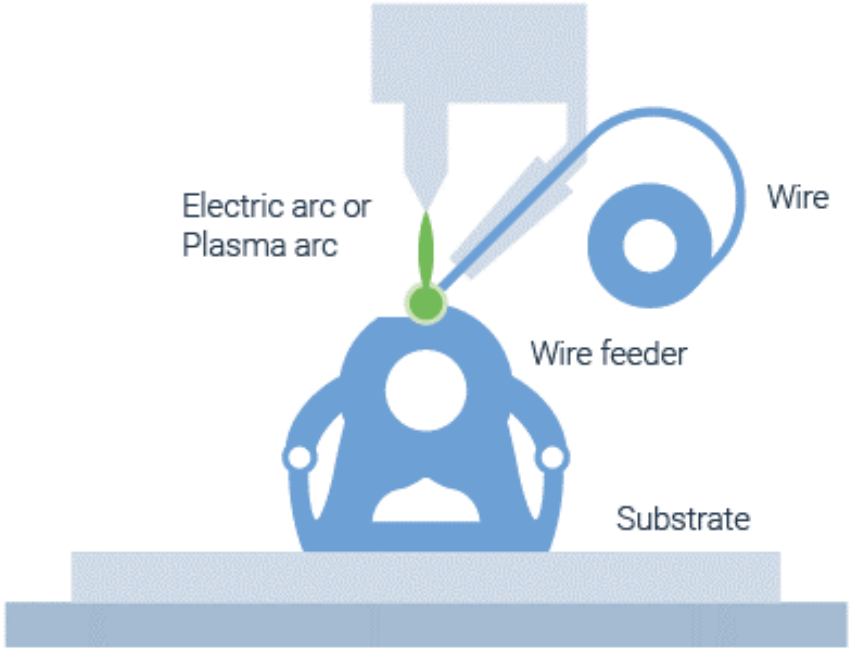
The CEMES I3D office proposes a pool of shared machines ... http://www.i3d.cemes.fr/

Fused Deposition Modeling (fdm)

What's coming out of the 3D printer ?



Cleaning by immersion : support material (brown material) is soluble
! two different materials


Electric arc or
Plasma arc
Wire
Wire feeder
Substrate

IPHC 3D fdm printer
‘ZORTRAX M200’

Direct 3D printing or through SD card storage

goal :
good Design and final parts

Maximum printing size :
200x200x180 mm

Layer thickness : 0.09, 0.14 or 0.19 mm

Printing time :
0.5 – 72 hours / peace

Used material : ABS (several colors)

Used with raft and support : ABS

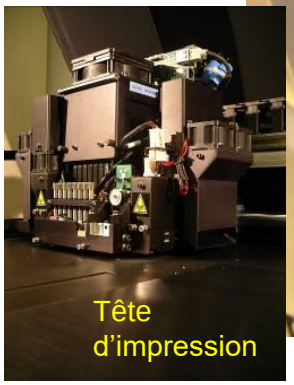
Price : ~2000 € HT
Test review : http://www.lesnumeriques.com/imprimante-3d/zortrax-m200-p22789/test.html
Seller : http://www.machines-3d.com/

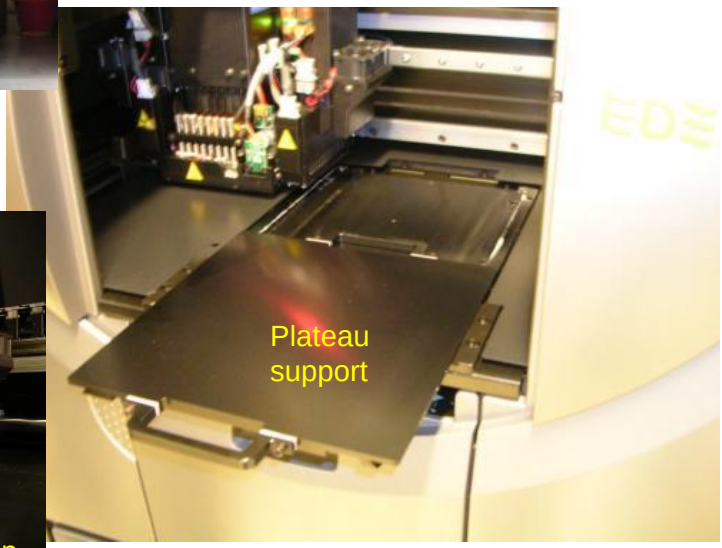
Photopolymer with UV curing with CADINDUS Society (Mulhouse, F) and pôle ORTECH from LpoDeck (Guebwiller, F)

Photos INTERNET (Société OBJET)

Bimaterial production (with CONNEX 500)

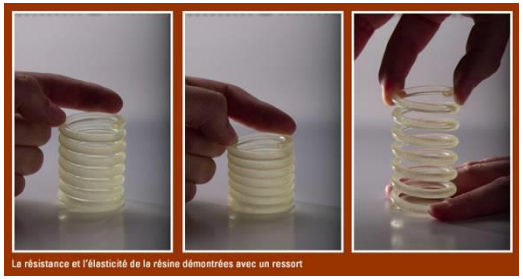
Unremovable parts : bearing



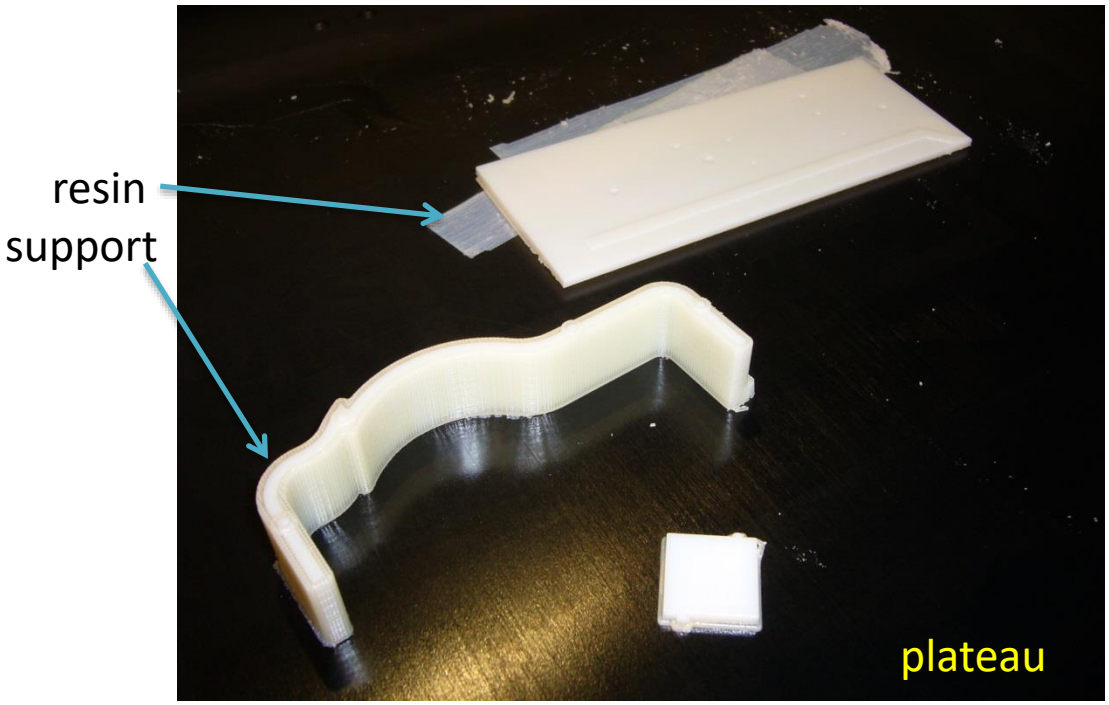


EDEN machine
by OBJET Society

spring

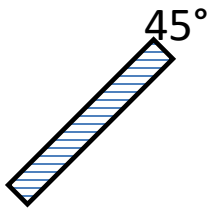


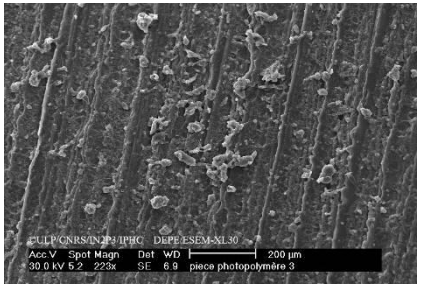
Photopolymer UV curing

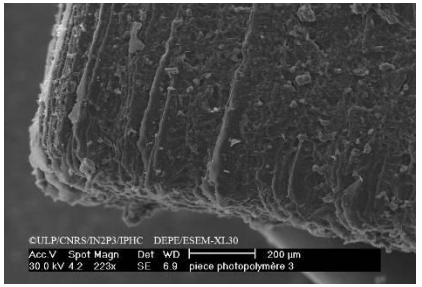


Cleaning : water jet and scraper
! resin support and part : same chemical base

3D printing with EDEN 330, viewed by electron microscope ESEM (IPHC)

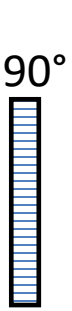


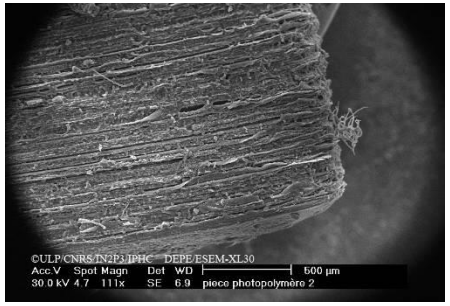


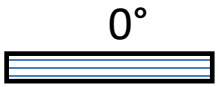


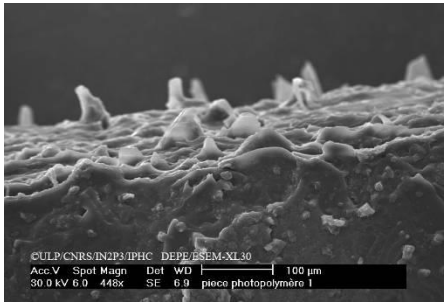
Sample fabrication
10mm x 10mm x 1mm

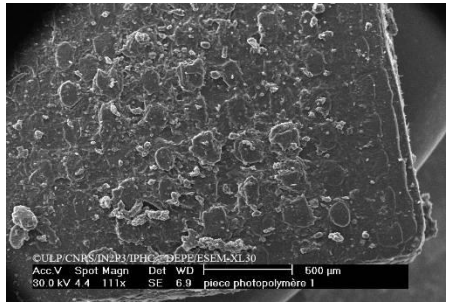
Layers thickness : 16µm











©IPHC / DEPE / ESEM : Environnemental Scanning Electron Microscope
Source : http://en.wikipedia.org/wiki/Environmental_scanning_electron_microscope

Selective laser sintering (sls)

PA parts production at LpoDECK and 3DPROD (France)

Ofen temperature : 170°C + laser
Layer thicknesss : ~100 µm

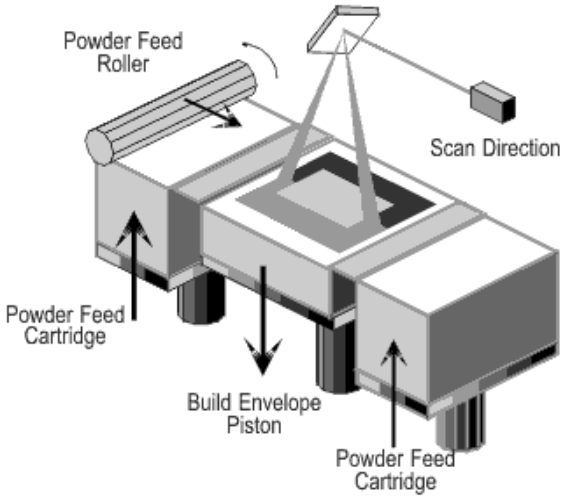
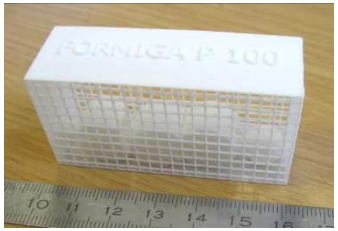


Image source : http://3dprinting.com/

EOS sample



Ensemble indémontable
Couches d'épaisseur 0.1mm

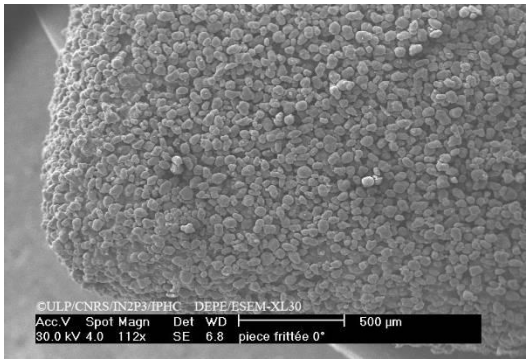
EOS Formiga P100 : Polyamid (PA) printing

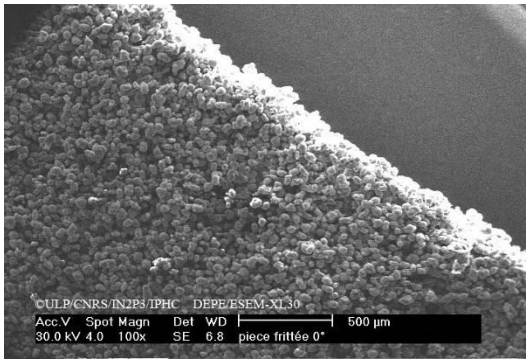
metal or ceramic possible on other machine

3D printing with EOS FORMIGA 100, viewed under ESEM (IPHC)

Powder grain size less than 100 µm

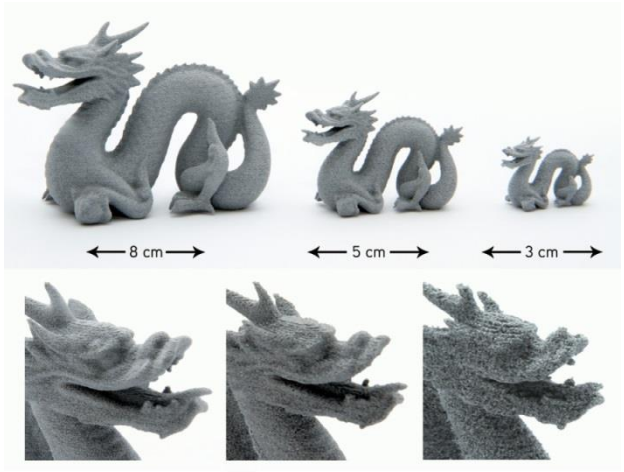
Partially melted on surface



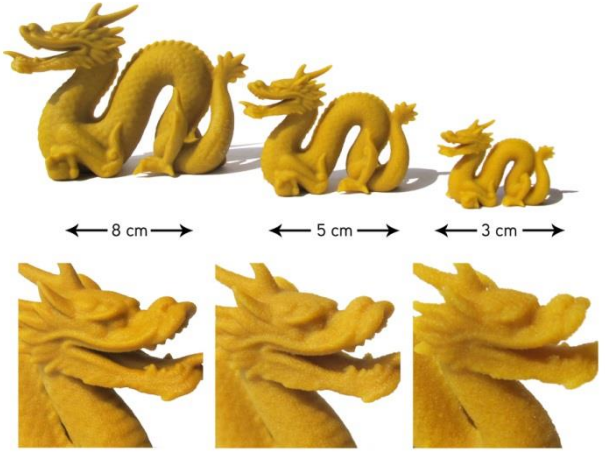


©IPHC / DEPE / ESEM : Environnemental Scanning Electron Microscope

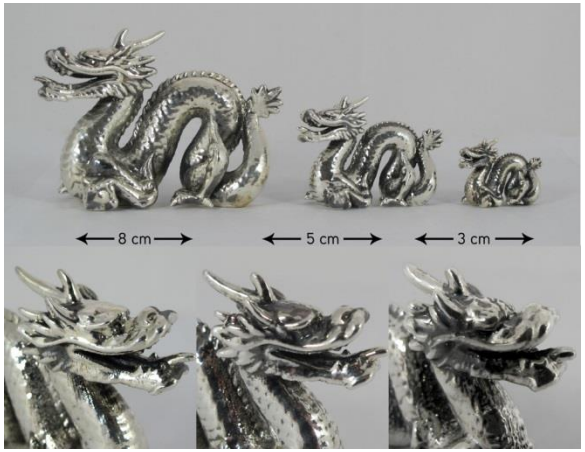
Scale effects



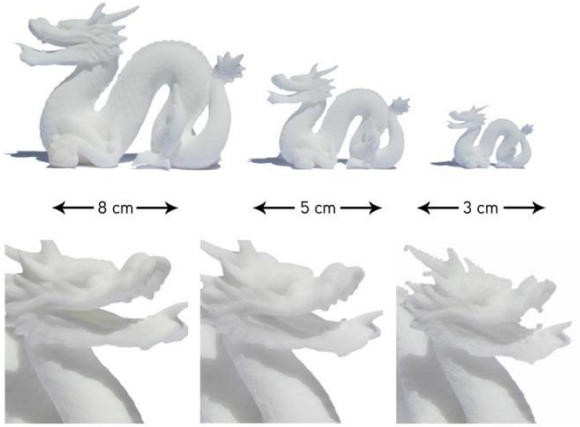
alumide



zcorp



argent



eos

sculpteo Source : http://www.sculpteo.com/fr/help/

Stereolithography (SLA)

Photo-solidification : 3D printing patent (1986)
Using of a vat of liquid ultraviolet curable photopolymer and ultraviolet laser

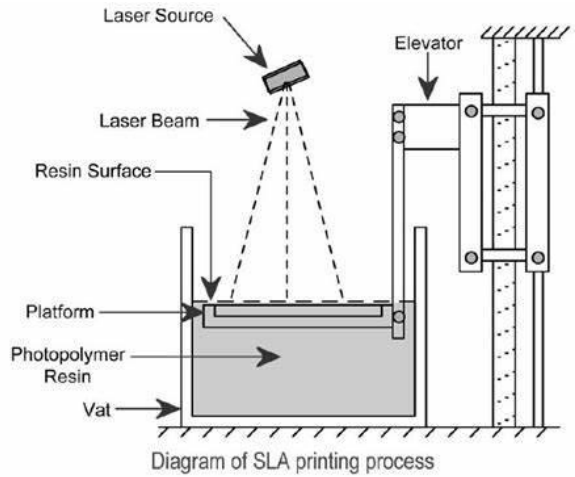
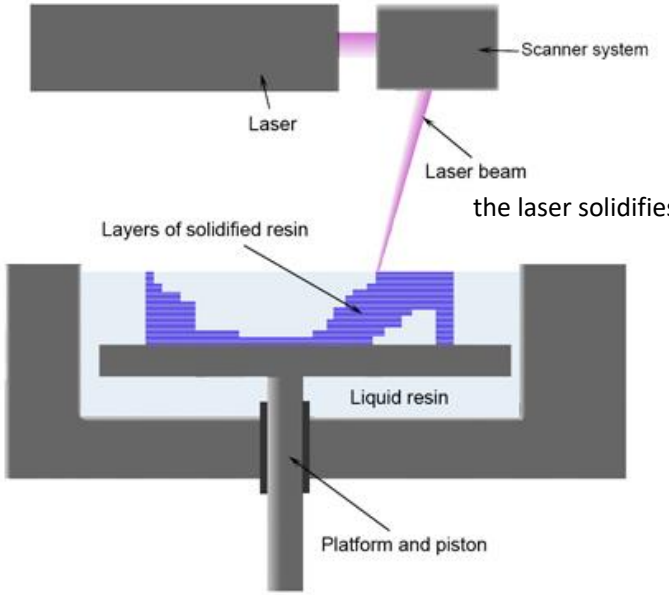


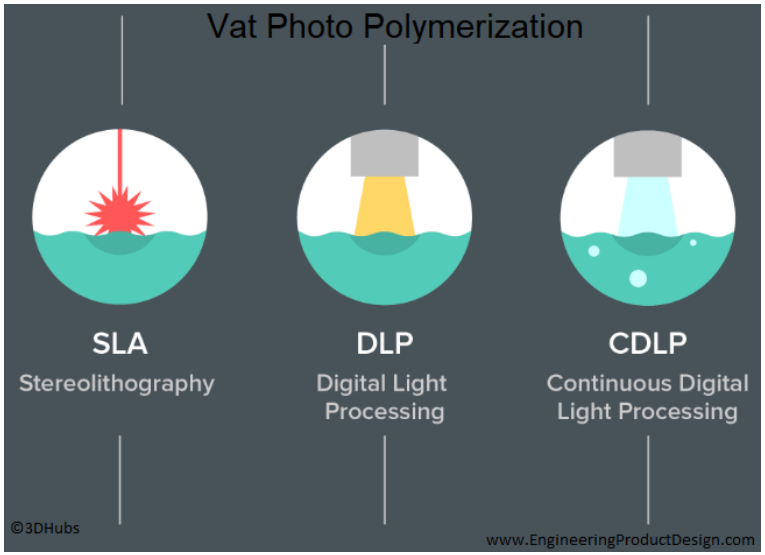
Diagram of SLA printing process

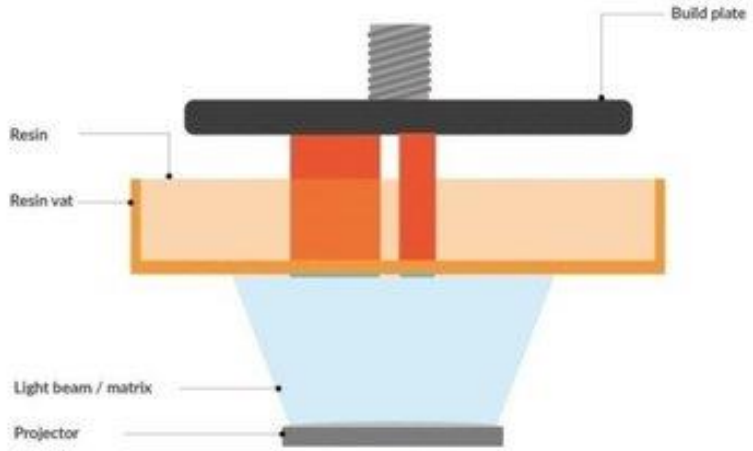


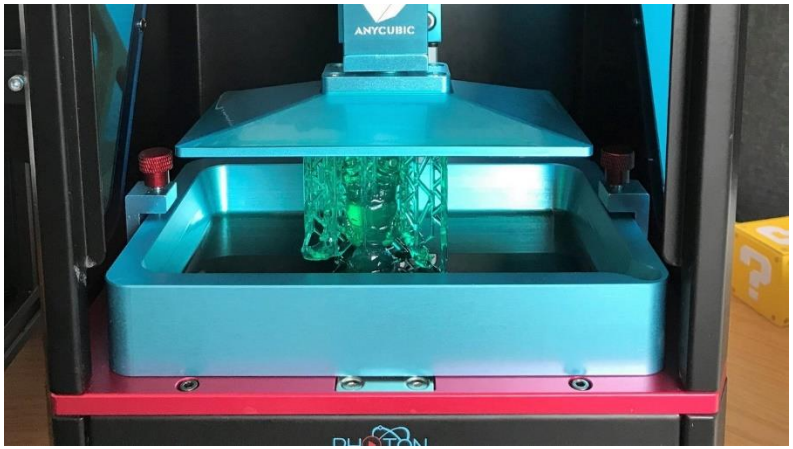
the laser solidifies the liquid surface

Source : http://en.wikipedia.org/wiki/Stereolithography

Digital Layer Polymerization



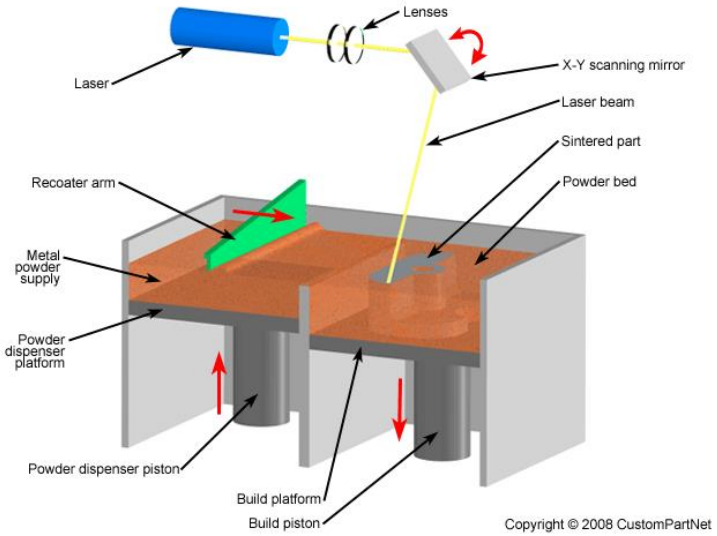




Source : http://www.EngeneeringProductDesign.com
https://all3dp.com/2/what-is-a-dlp-3d-printer-3d-printing-simply-explained/

Direct Metal Laser Sintering (DMLS)

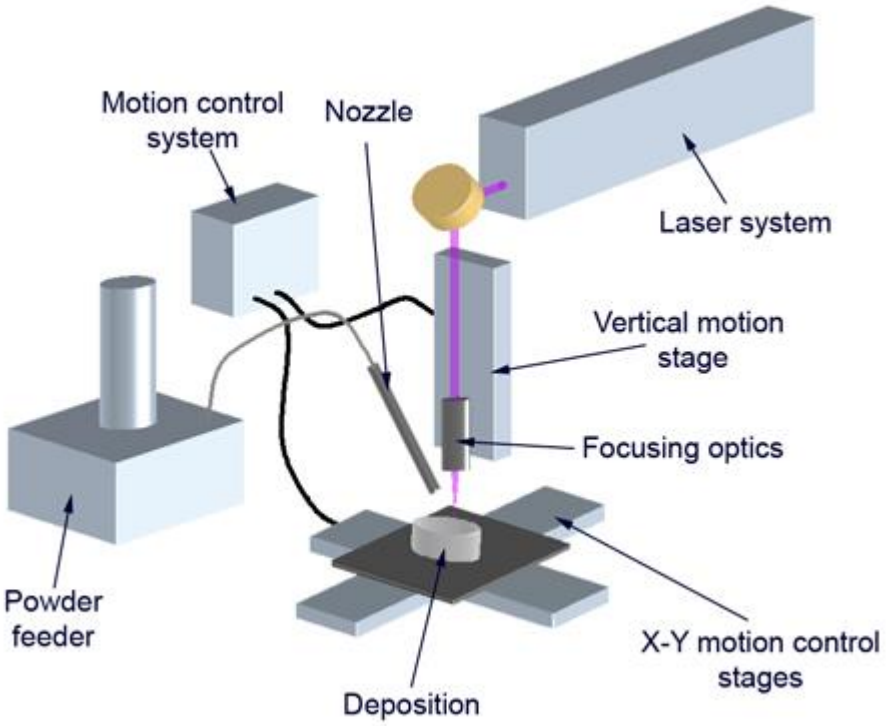
Today, the way to produce metal parts…



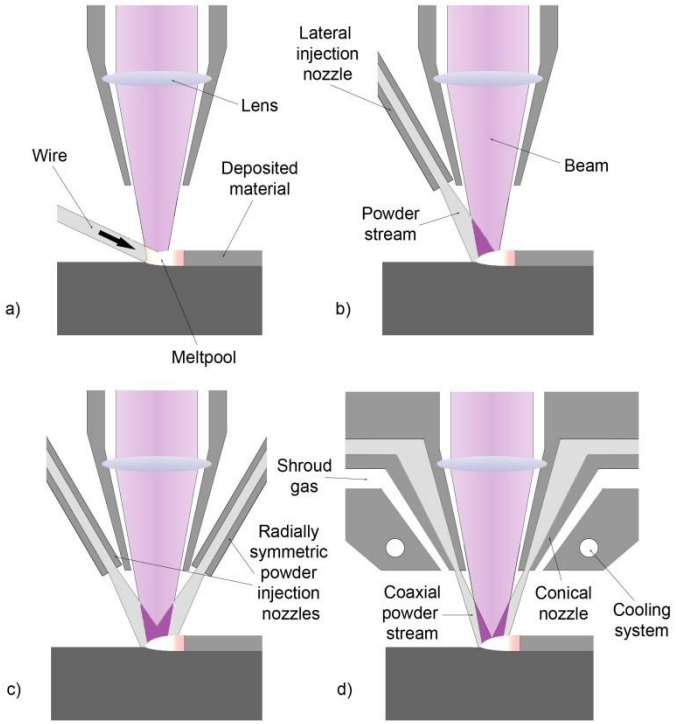
Laser : ~200 W
Layer thicknesss : ~20 µm or less

Image source : http://www.custompartnet.com/wu/direct-metal-laser-sintering/

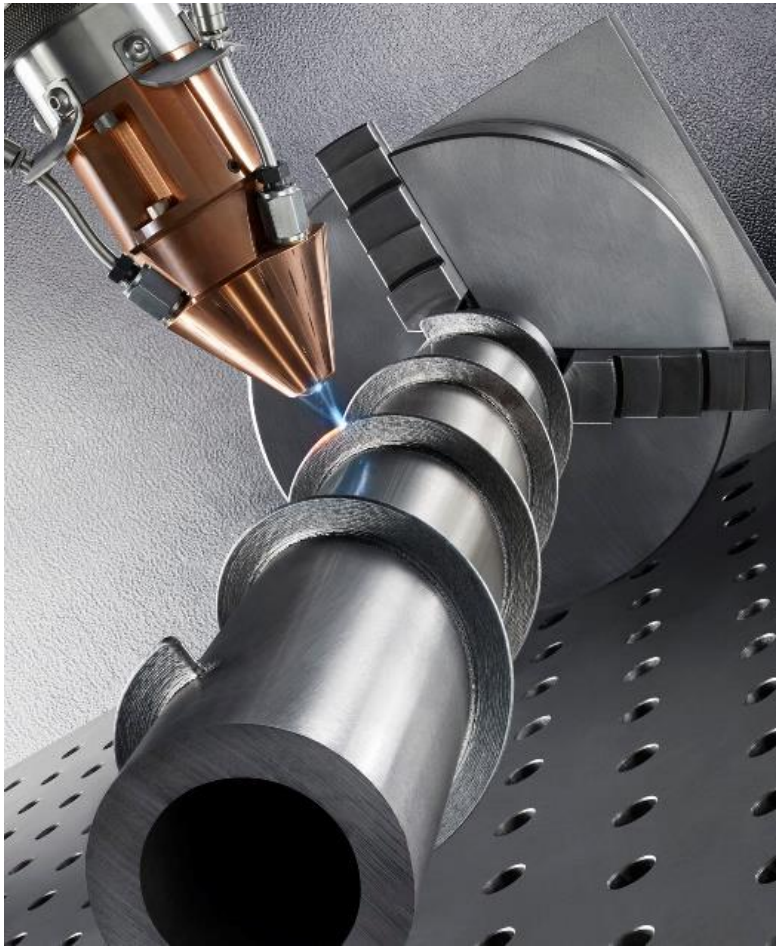
Laser cladding (CLAD)



Source : http://en.wikipedia.org/wiki/Cladding_(metalworking)

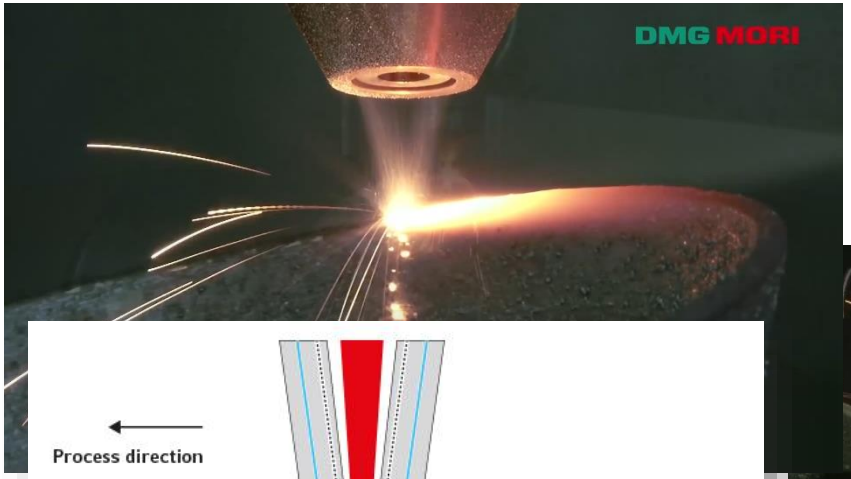


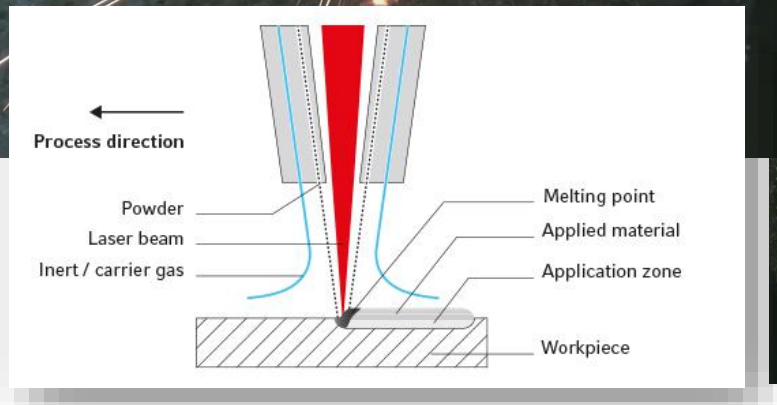
Source : https://www.3dprintingmedia.network/america-makes-ansi-launch-phase-2-amsc/



Source : http://www.fabricatingandmetalworking.com/2016/07/additive-manufacturing-making-sense-laser-metal-deposition-3d-printing/

DMG MORI
LASERTEC 65 AM
special manufacturing machine





- **Laser CLADDING**
- **Machining**
- **Repairing**
- **Coating**

Source : http://www.dmgmori.com/webspecial/journal_2014_1/en/lasertec-65.htm

2- Main 3D additive manufacturing technics in use

1- **fdm process** (fused deposition molding) : thermoplastic fused deposition / extruder hole diameter ~ 0,4 mm

2- **Objets 3D printers** (Objet.com ; polyjet printing) : thin layers (less than 30 µm)
Remove with spatule, remove support material with water jet
Clear the tray with spray / Build tray is ready for the next model

3- **voxeljet** (voxeljet.com)
Pouder and binder jet
Parts complete curing after 24 h standing
Make vax parts for lost wax casting
Layer thickness 0,006 inch
Depoudering station to remove the pouder by hand to prevent damage
Final curing process : low temperature for 5 h
When curing is complete, remaining excess pouder is removed with low pressure air jet
Final step : quick dip in vax to seal the part
A heater can as used to remove the excess vax from the surface

4- **stratoconception**
Cutting parts in thin hard or soft plates (foam, wood, plastic, metal, …)
Stack the pieces to construct the whole geometry

5- **stereolithography** (materialise.com ; SLA = StereoLytography Apparatus)
Pieces are produced in liquid polymer, with a same material builded supporting structure.
The polymer is solidified layer by layer : during the process, the pieces supporting tray go down in the polymer.

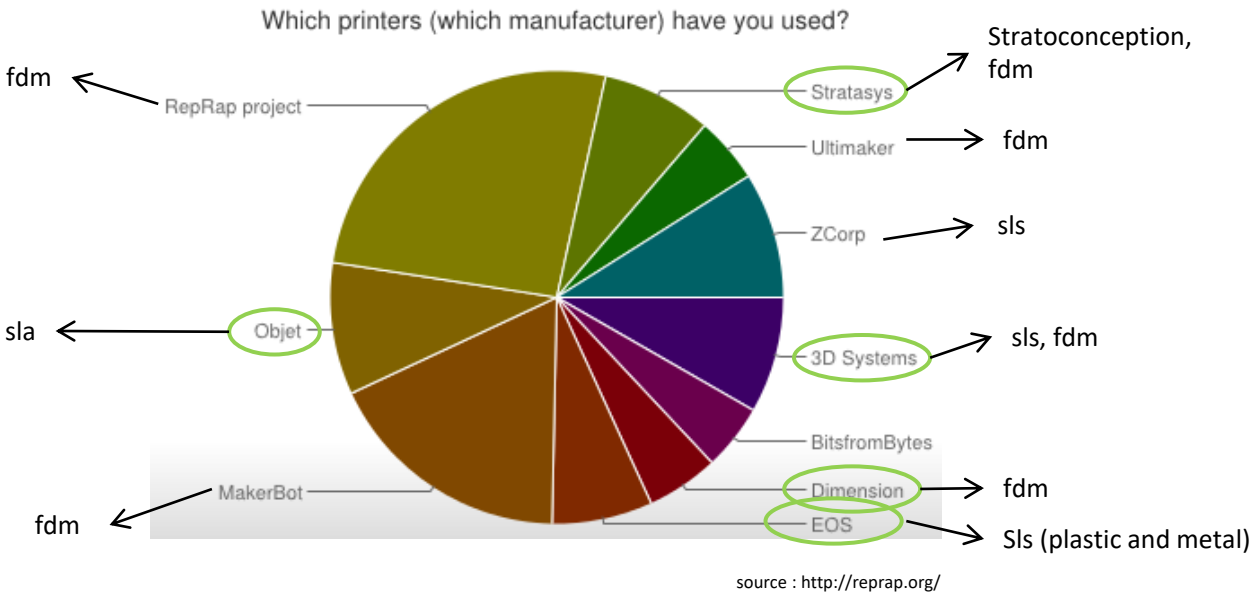
6- **polyshape process** (SLS = Selective Laser Sintering ; DMLS = Direct Metal Laser Sintering, SLM = selective laser melting)
Pouder layers with selective laser melting or sintering, layer by layer (plastic or metal)
The support, the pouder and the pieces are cooled before cleaning

7- **CLADDING :**
Simultaneous metal powder projection and melting by laser : the melted powder solidifies and forms the part layer by layer. The support can be curved.

Sources : http://www.industrie-techno.com/sept-facons-de-fabriquer-en-3d.23174
http://en.wikipedia.org/wiki/Cladding_(metalworking)

2- Main direct fabrication technics in use

Several machine manufacturers …



source : http://reprap.org/

2- Main direct fabrication technics in use – Who could make the part ?