Spring 2014

CSCI 599: **Digital Geometry Processing**

14.2 3D Printing

Hao Li

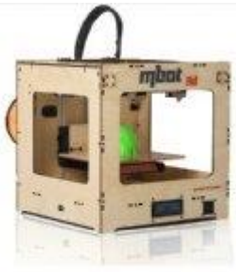
http://cs599.hao-li.com

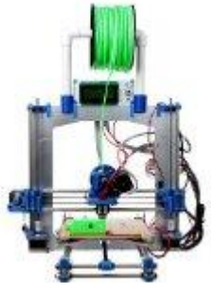
Why 3D Printers Become Popular?

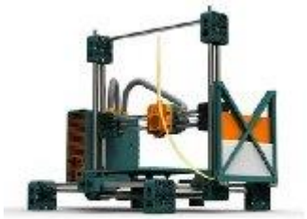
- Prices are dropping
  - Thousands of dollars to hundreds of dollars
- Smaller Sizes
  - Industry oriented vs. Home oriented (desktop)
- Stories

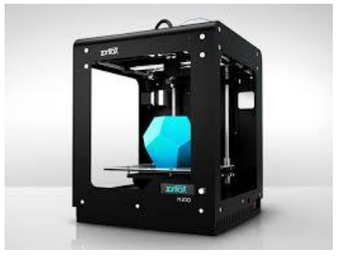
“The next revolution in manufacturing”
“May change economies globally”

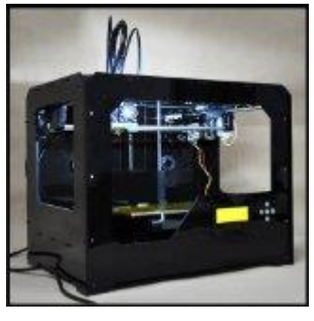
Desktop 3D Printers

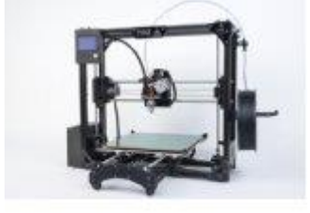




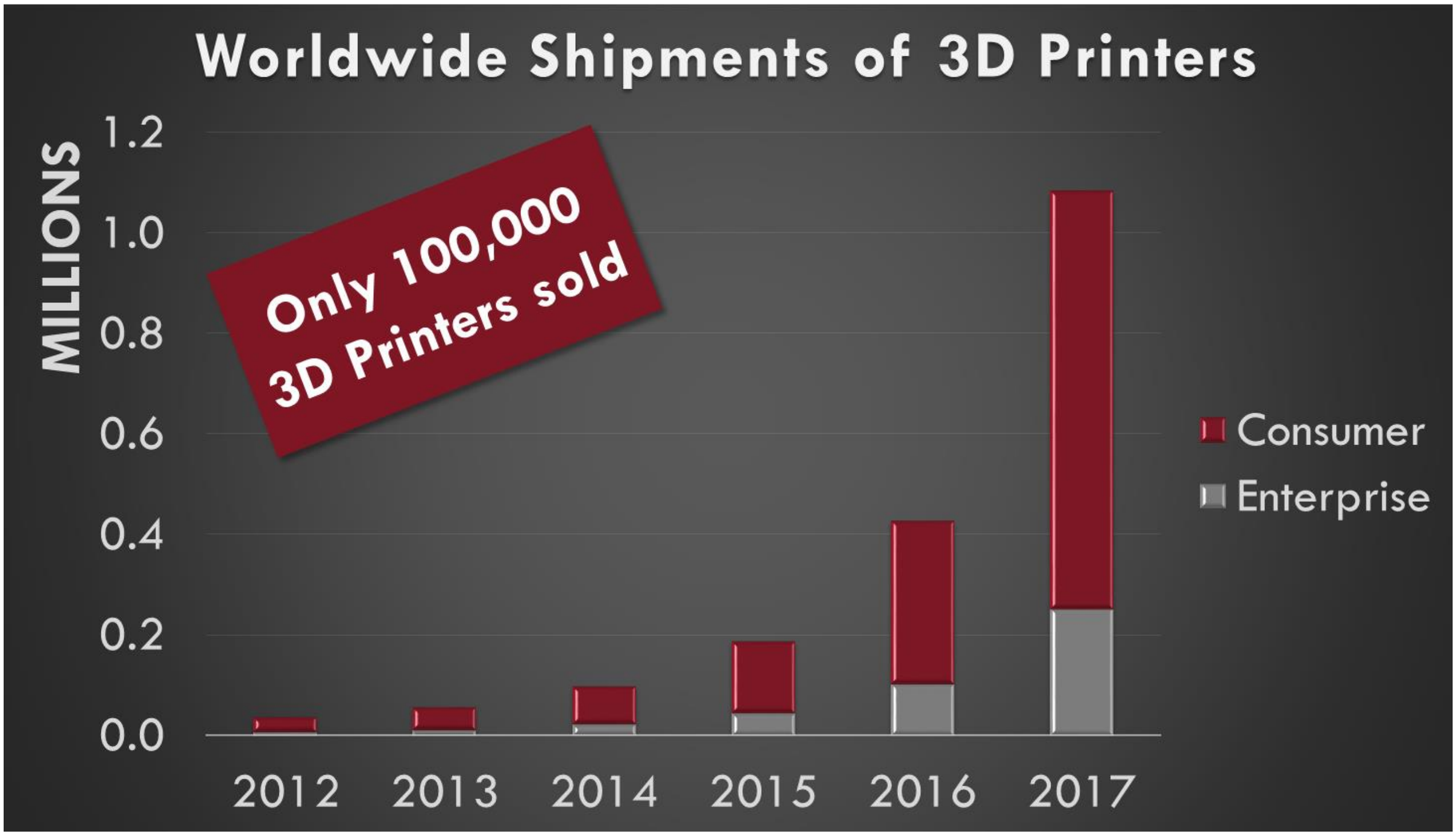








Where are we today?



Problem

Why haven't 3D Printers taken off?

ZEUS

scan print copy fax

New Communication Channel

Connecting Designers, Engineers, Manufacturers, and Clients via 3D Fax

Revolutionizing Online Shopping

Fitting before Online Shopping (3D Fax)

Instant Delivery (3D Fax)

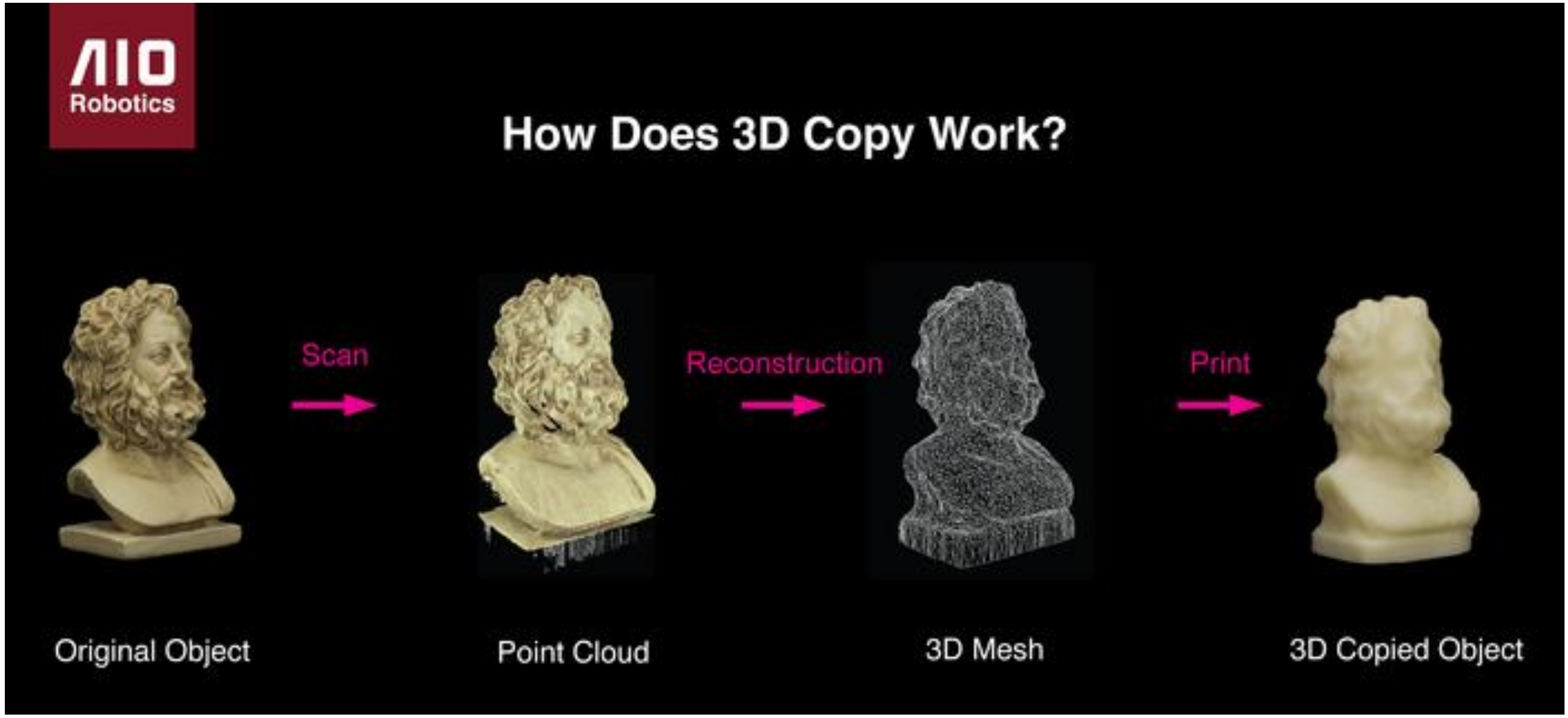
Customization

Customize Objects, Create Presents (3D Copy/Fax)

Vision (Video)

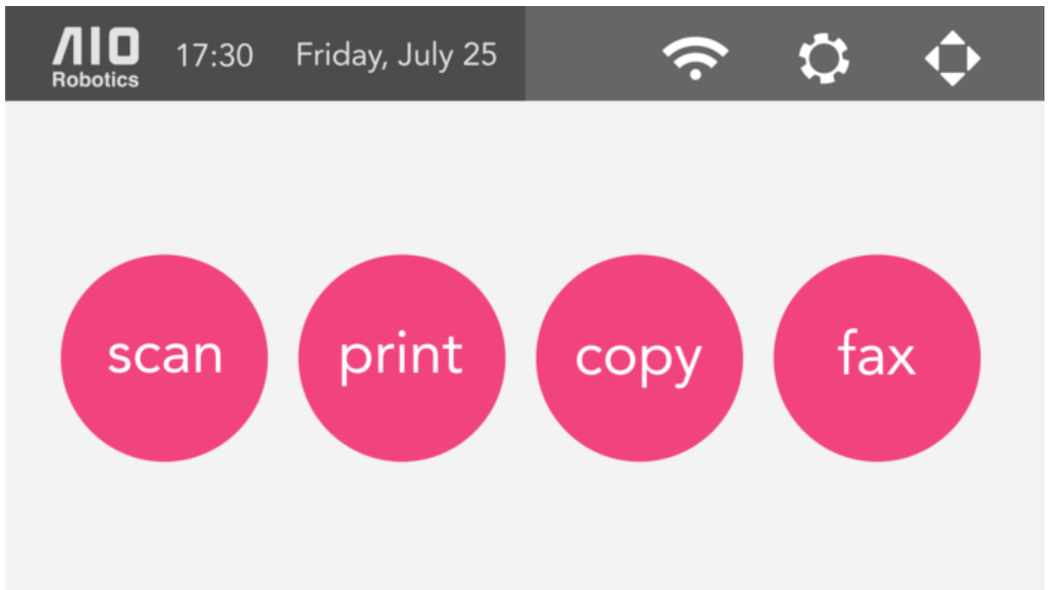
3D Scanning in ZEUS

Process

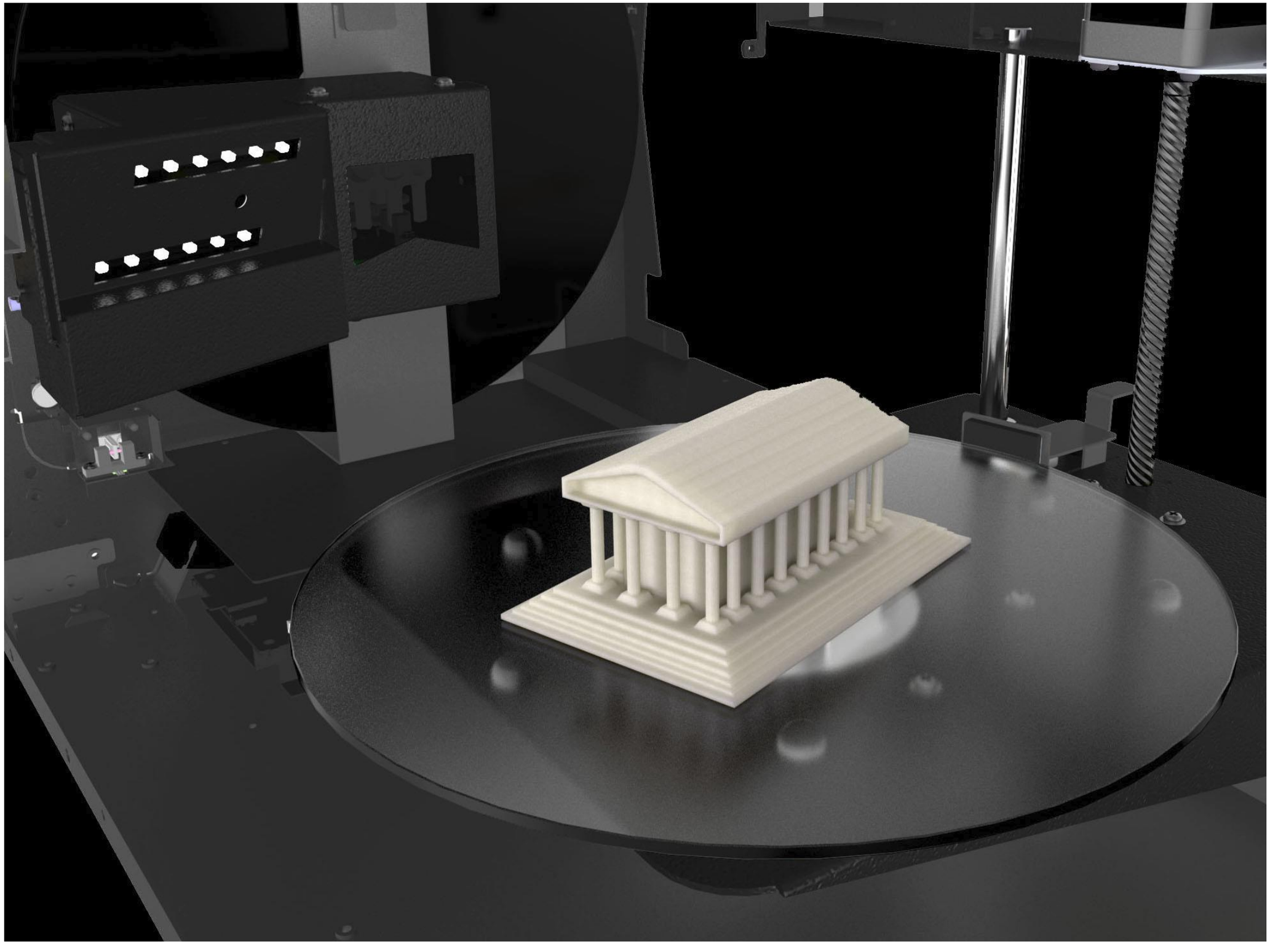

AIO Robotics
How Does 3D Copy Work?
Scan
Reconstruction
Print
Original Object
Point Cloud
3D Mesh
3D Copied Object

Scanning Requirements

- Automatic:
  - Take out all time-consuming tasks
  - Can have guided simple user involvements
- Accurate and printable results
- Fast and always display progress: Good UI relieve user anxiety



Scanning – Basic Technique



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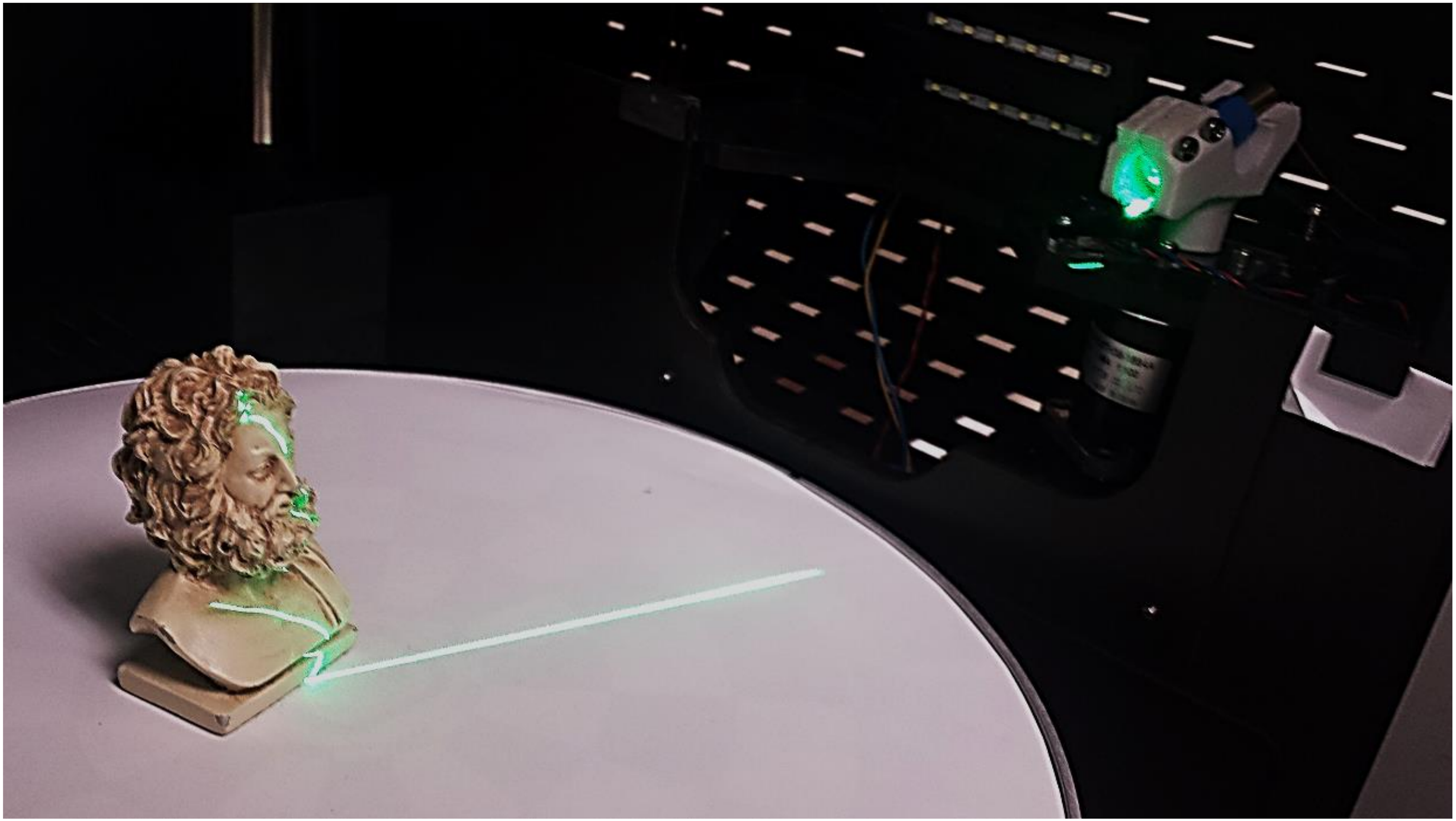


Scanning - Details

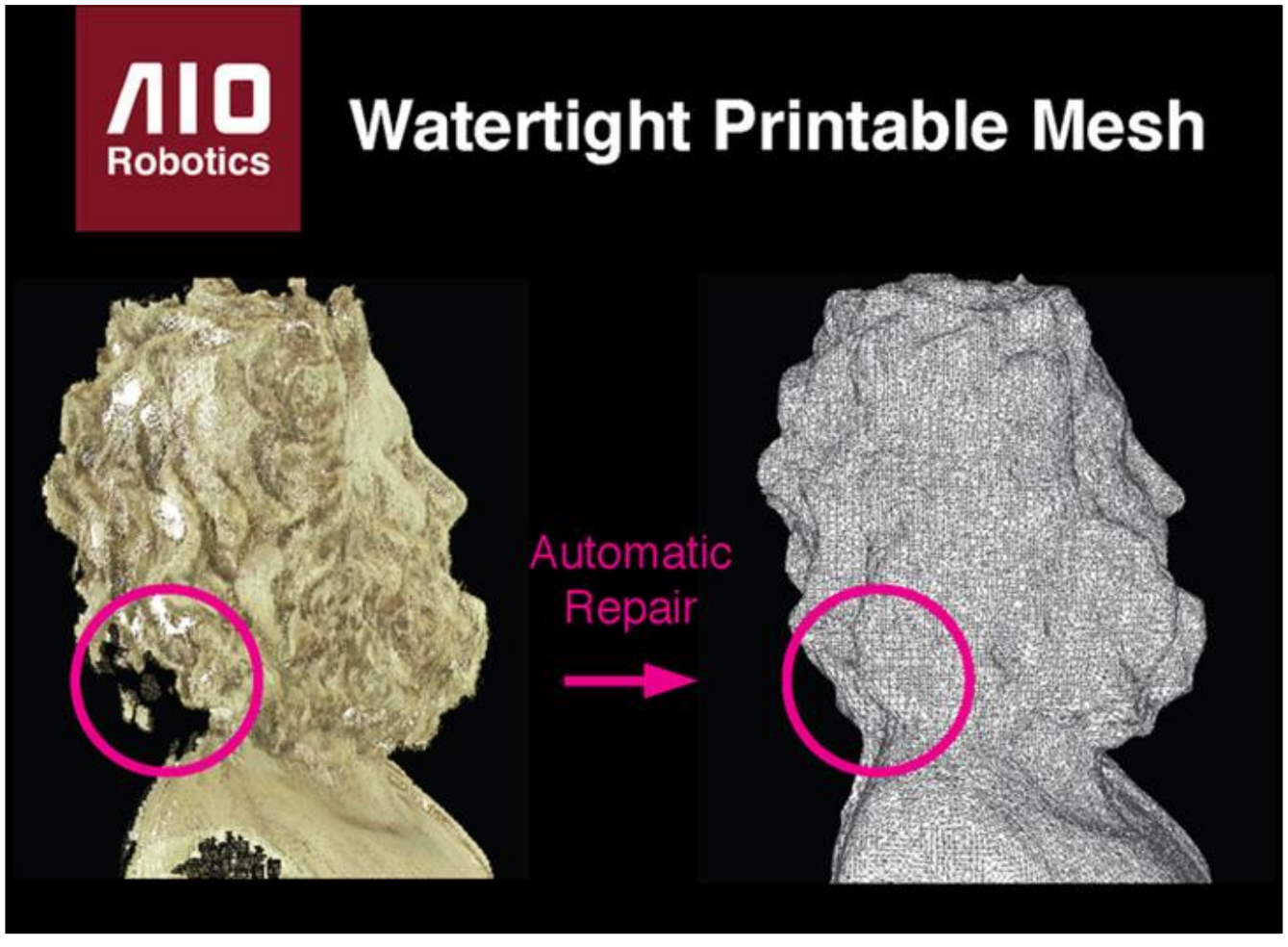
- Camera: Good quality camera; focused on the object
- Laser: Strong and thin laser
- Smooth laser motor to sweep the object

Future Expansion

- Larger items: More/moving laser, total redesign
- Smaller items: higher resolution cameras
- Faster scanning: Structured lights
- Automatic alignment for scanning base
- Occlusion detection: Moving turntable

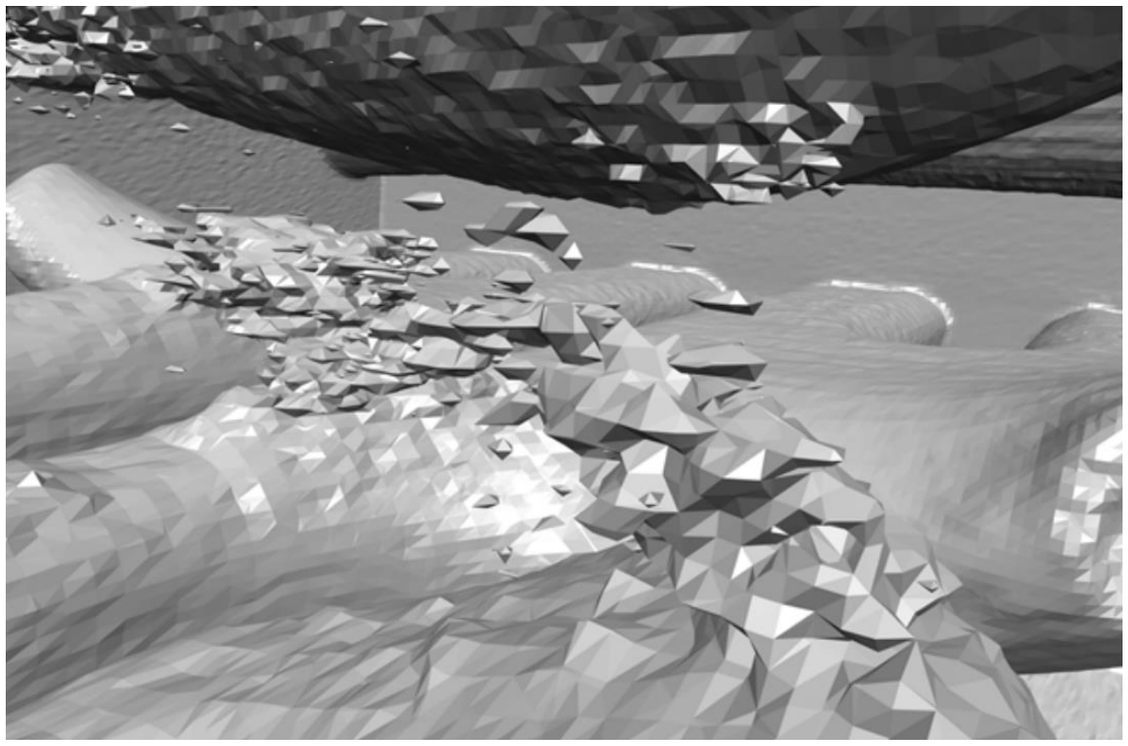
Meshing

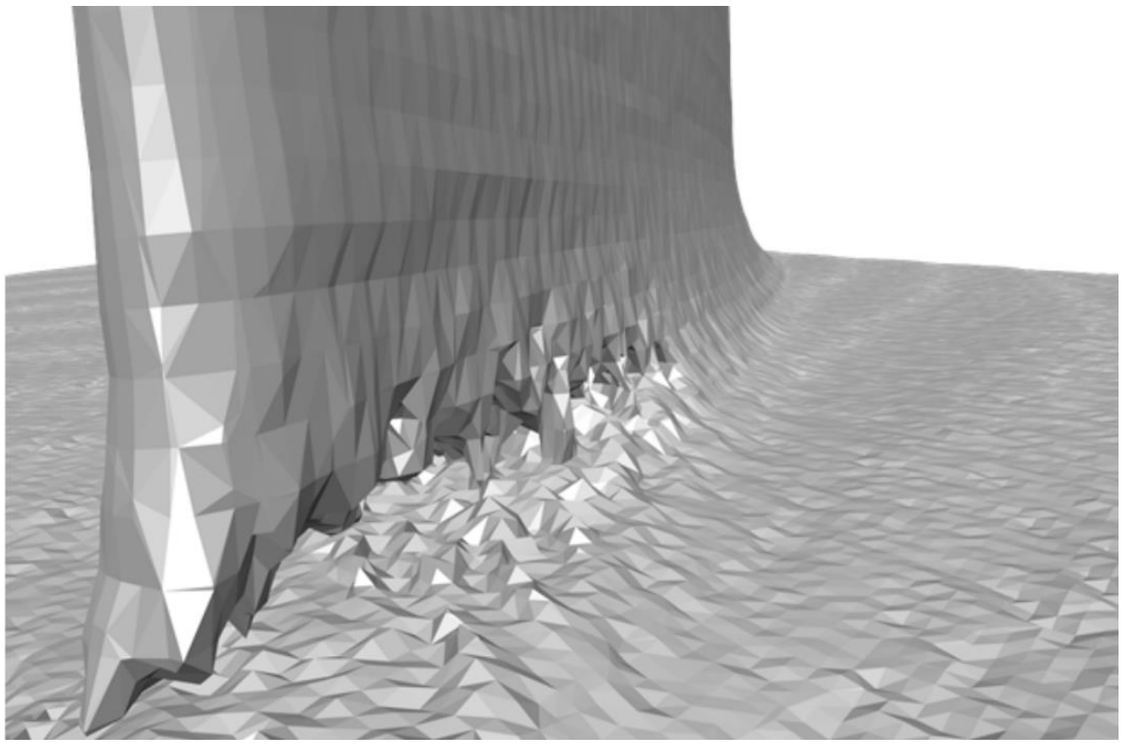
- Find manifold surface from the scanned point cloud
- Requirements:
  - Maintain as much recoverable details as possible (mostly on the point cloud)
  - 15 minutes on an ARM/embedded processor
- Steps:
  - Reduce the number of points
  - Normal smoothing/estimation
  - Surface reconstruction: Poisson Reconstruction



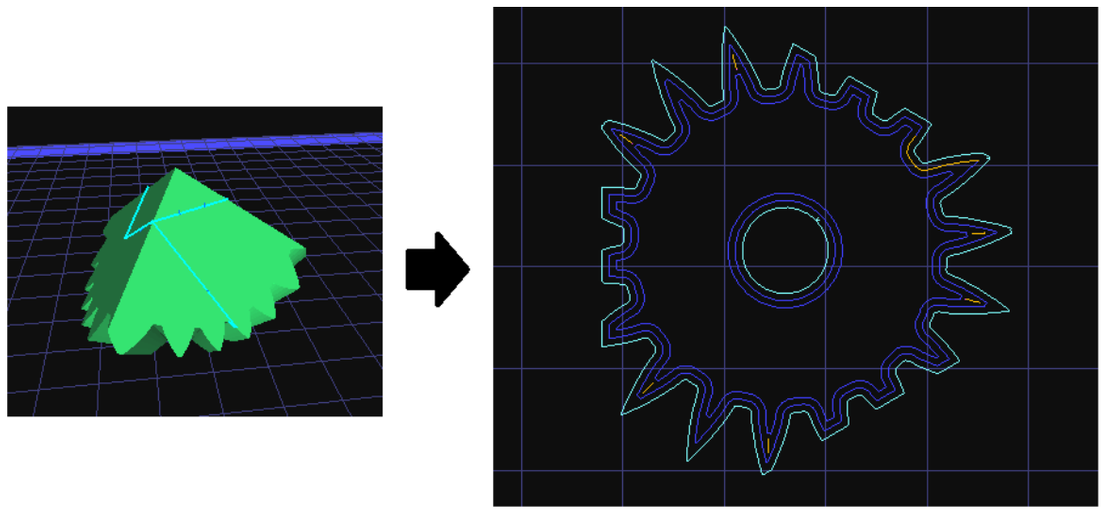
Mesh Repair

- Adapt raw mesh for printing
- Watertight globally consistent manifold
- Removes:
  - Singularities, self intersections, degenerate elements, spurious geometry, topological noise

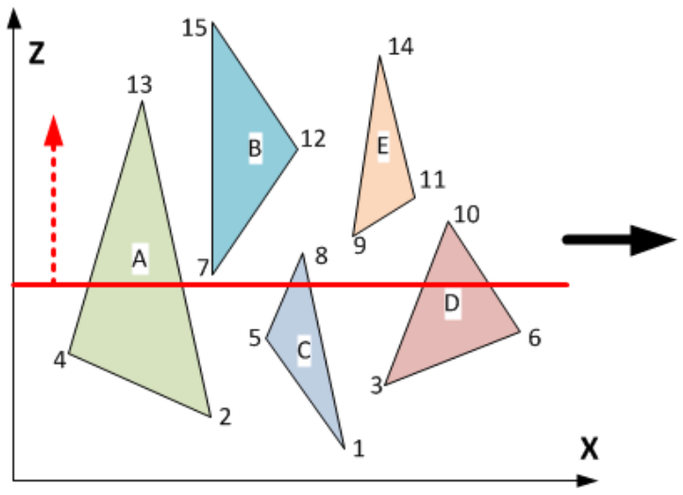




Slicing



- Cut solid into thin slices to be printed layer by layer
- Software: Cura, Slic3r, KISSlicer: gcode
- Both computational and practical
- Print through intersecting triangles in each plane at specified infill percentage
- Reduce strings/seams

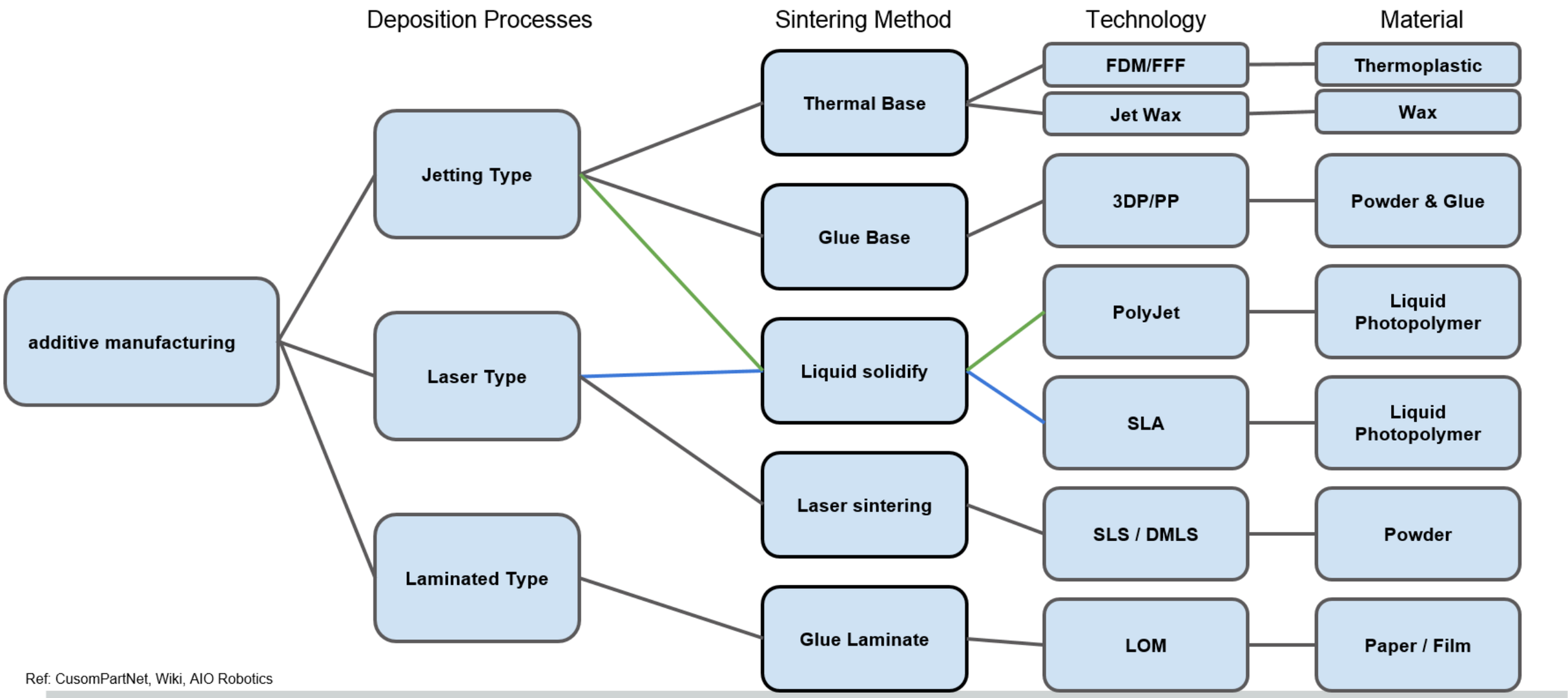


Triangle bottom list
1 -> C
2 -> A
3 -> D
7 -> B
9 -> E

Triangle top list
8 -> C
10 -> D
13 -> A
14 -> E
15 -> B

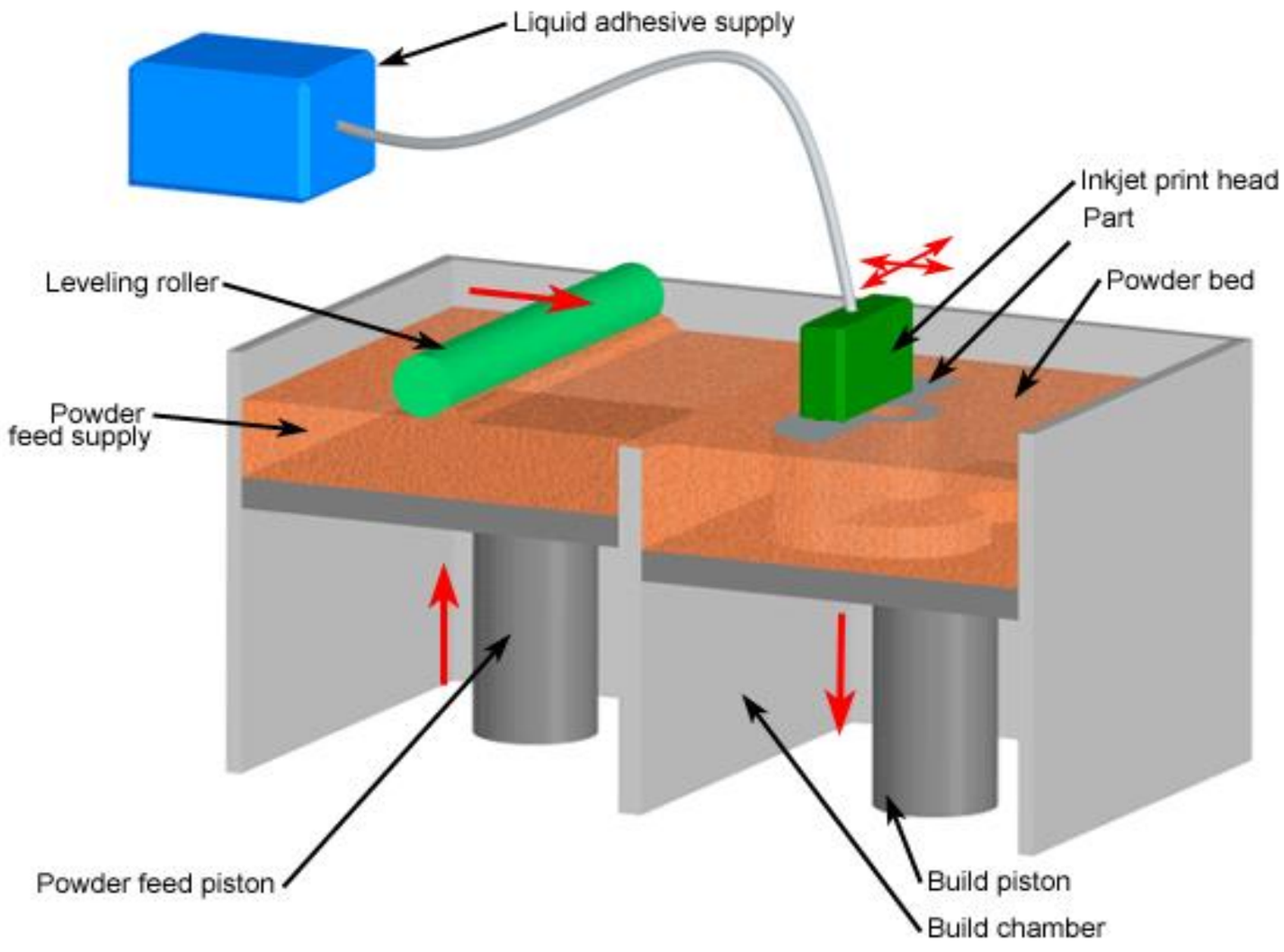
3D Printing

Type of 3D Printing Technology



Ref: CusomPartNet, Wiki, AIO Robotics

3DP – 3D Printing and Gluing



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1. Apply Powder on the printing bed
2. Use inkjet head to apply glue on build area
3. Lower the printer bed
4. Repeat the process until done
5. Remove Unbounding powder
6. Dip to polymer for coating

3DP – 3D Printing and Gluing

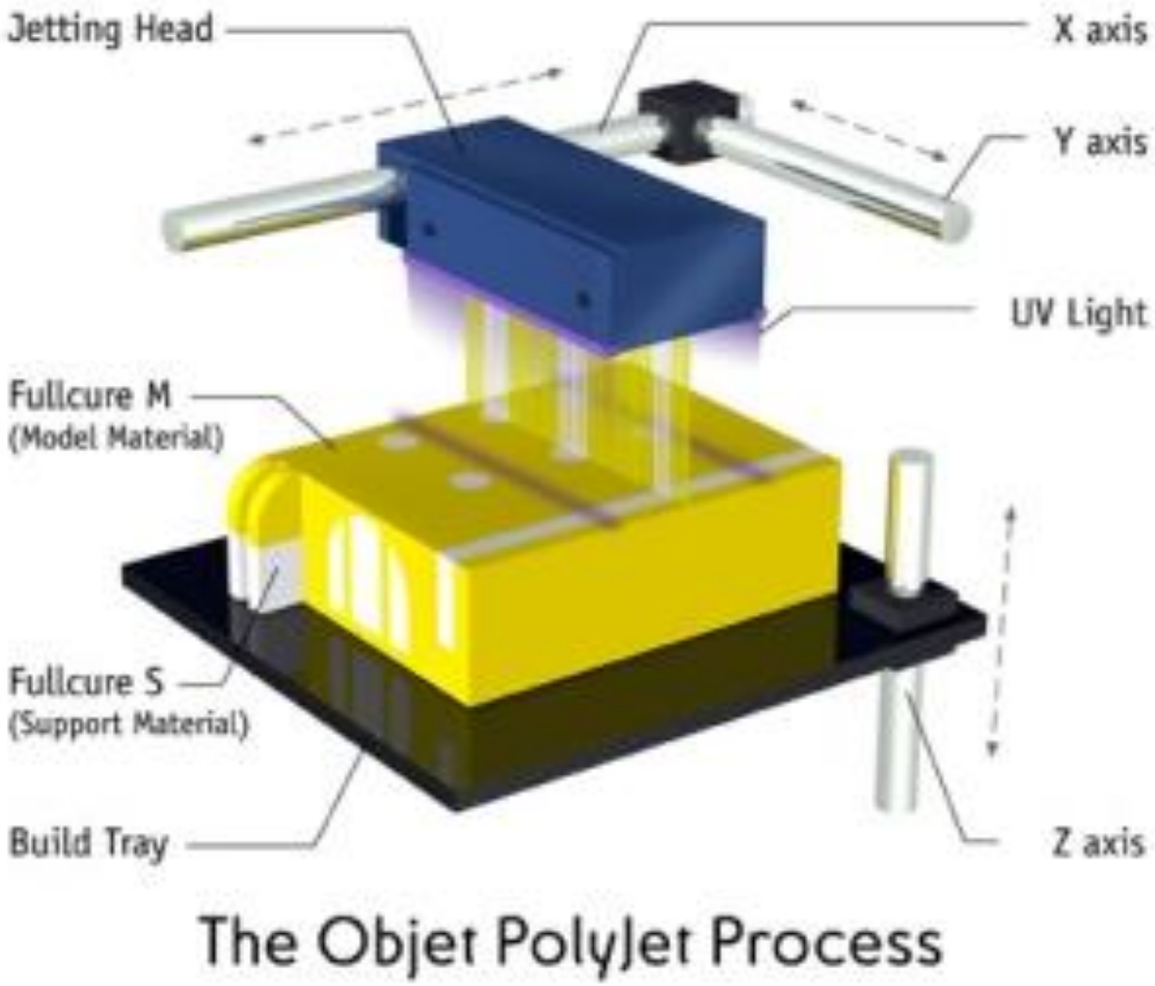
Pro:

1. Full Color Support
2. Medium detail of part
3. Non-toxic material

Con:

1. Parts are rough & weak
2. Mess to clean up
3. Machine are big and expensive ($30K~$110K)

Polyjet – Jetted Photopolymer

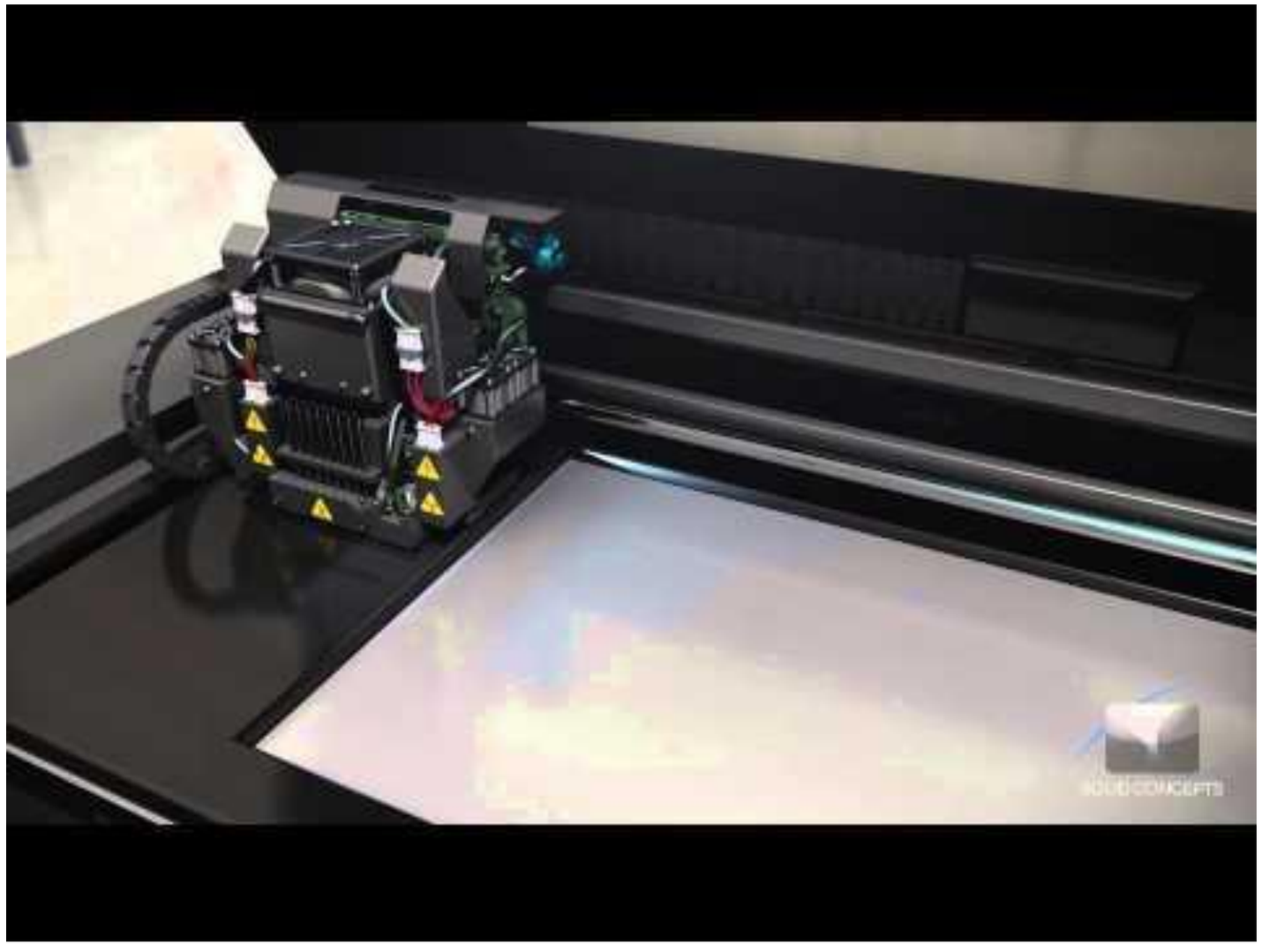


The Objet PolyJet Process

1. Jet with polymer material
2. Use UV Light to cure polymer
3. Lower the printer bed
4. Repeat the process
5. Debonding support material

Ref: http://www.3daddfab.com/technology/ , CustomPartNet

Polyjet – Jetted Photopolymer



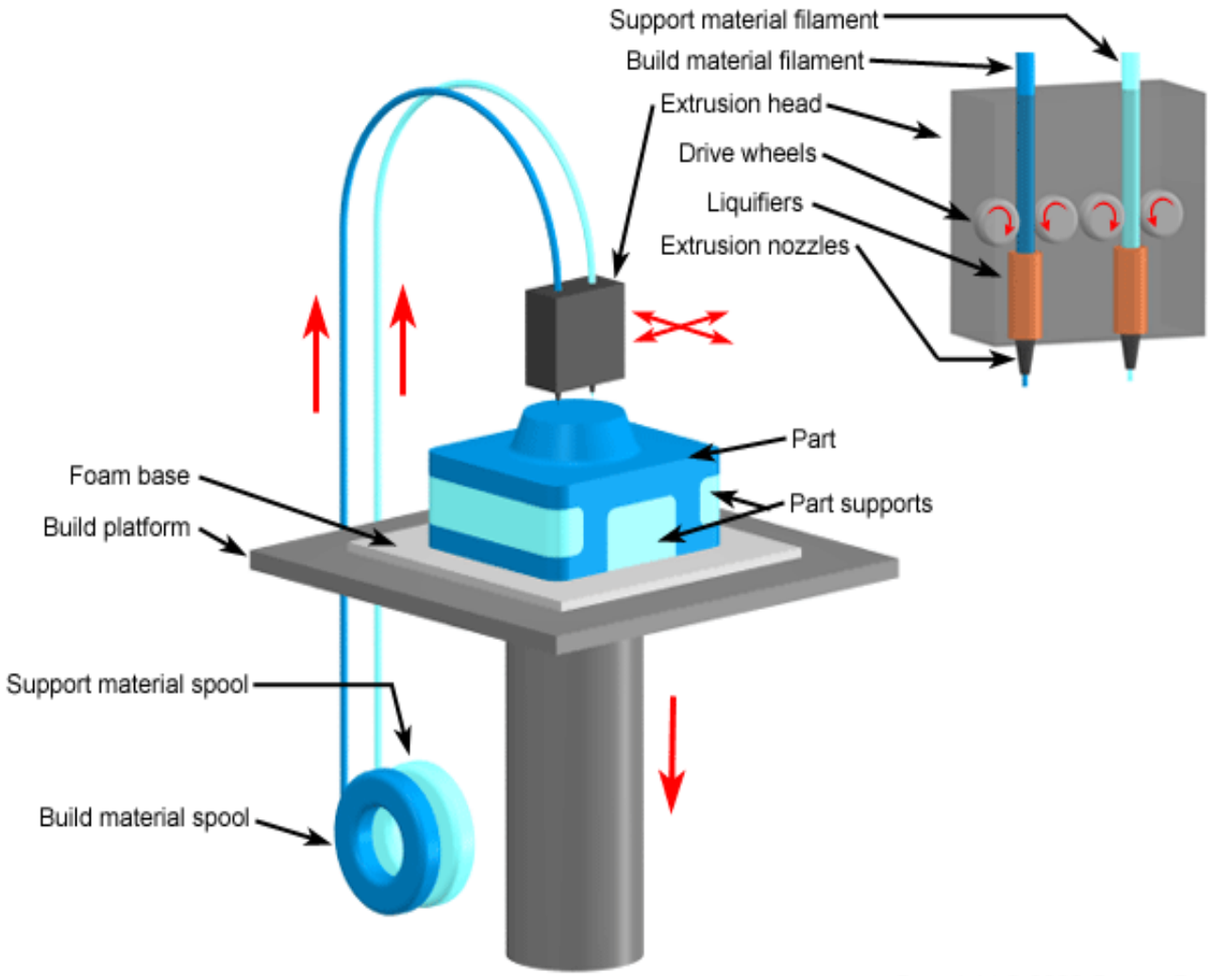
Pro:

1. Detail of surface finish
2. Translucent parts
3. Complex geometries

Con:

1. Poor Strength
2. Toxic material
3. Limited Color
4. Expensive ($20K~$750K)

FDM (Fused deposition modeling) and FFF (Fused Filament Fabrication)



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1. Heat plastic filament
2. Extrude liquid plastic on the bed
3. Lower the printer bed
4. Repeat the process until done
5. Remove Support Material

FDM (Fused deposition modeling) and FFF (Fused Filament Fabrication)

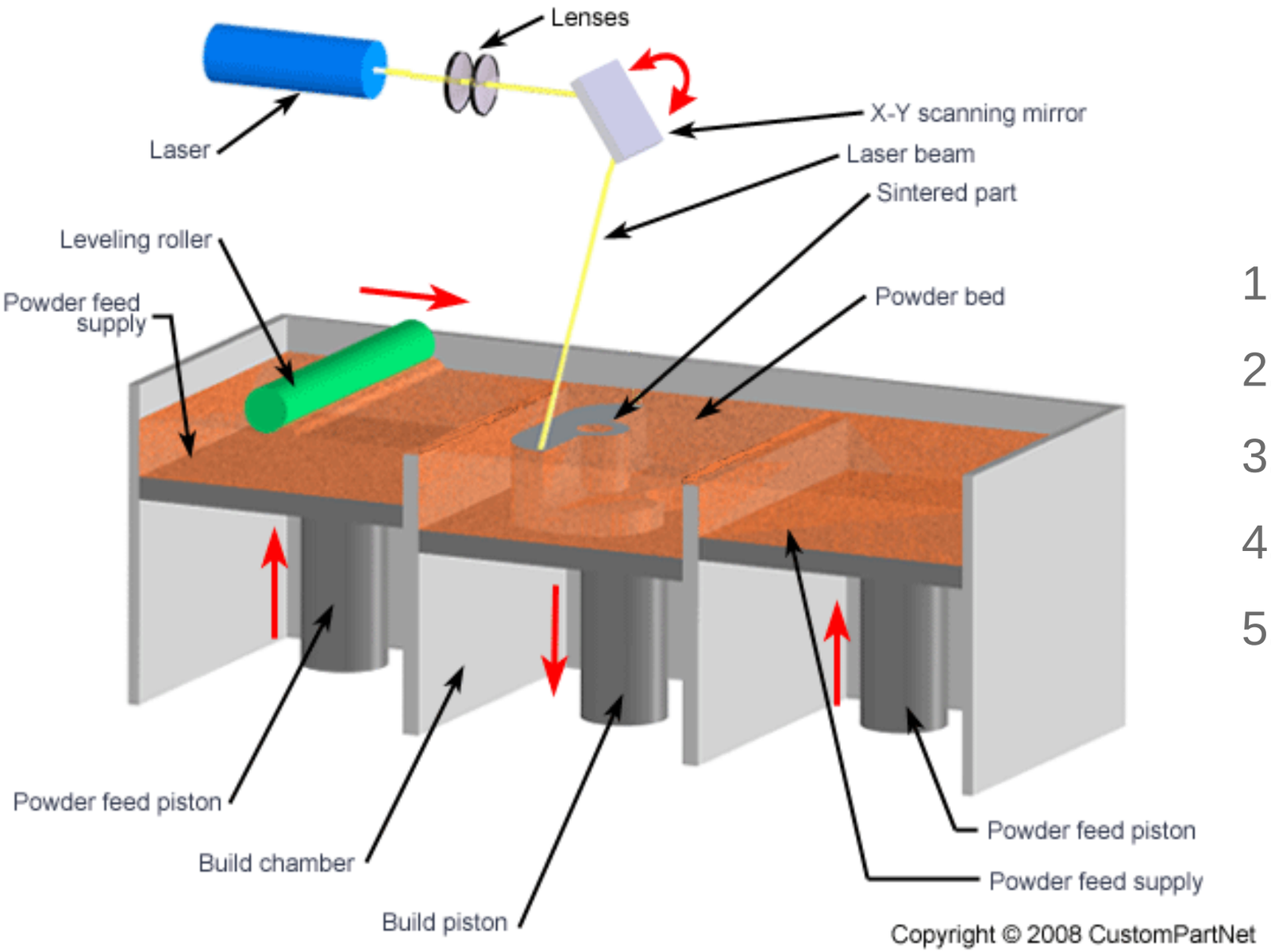
Pro:

1. Open Source & Most popular
2. Inexpensive ($199~$199K)
3. Strong and Functional parts
4. Variety of material & Color
5. Non-toxic
6. Easy to clean up

Con:

1. Poor Surface Finish
2. Limited detail
3. Layers bond are weaker

SLS (Selective Laser Sintering) and DMLS (Direct Metal Laser Sintering)



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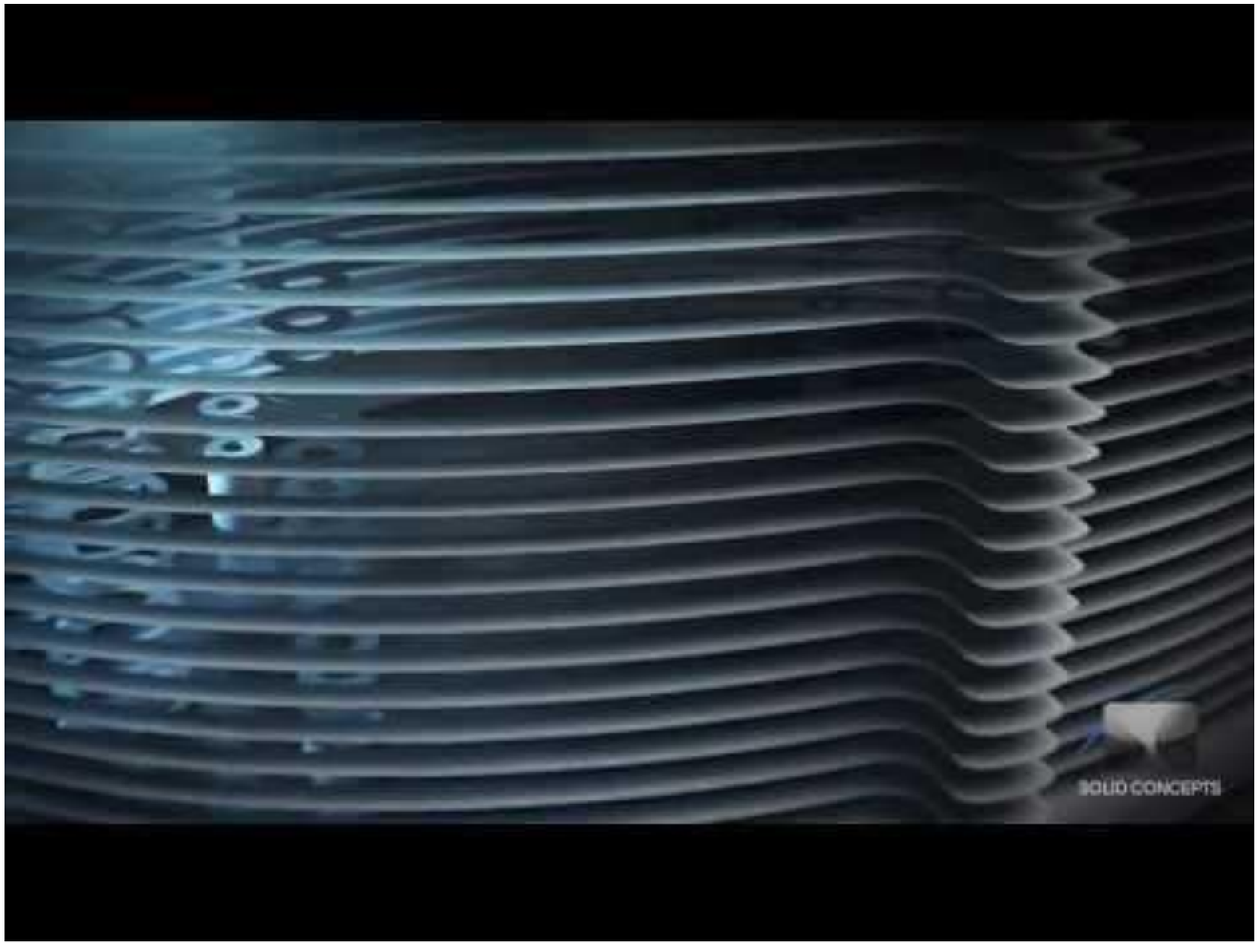
SLS – Selective Laser Sintering



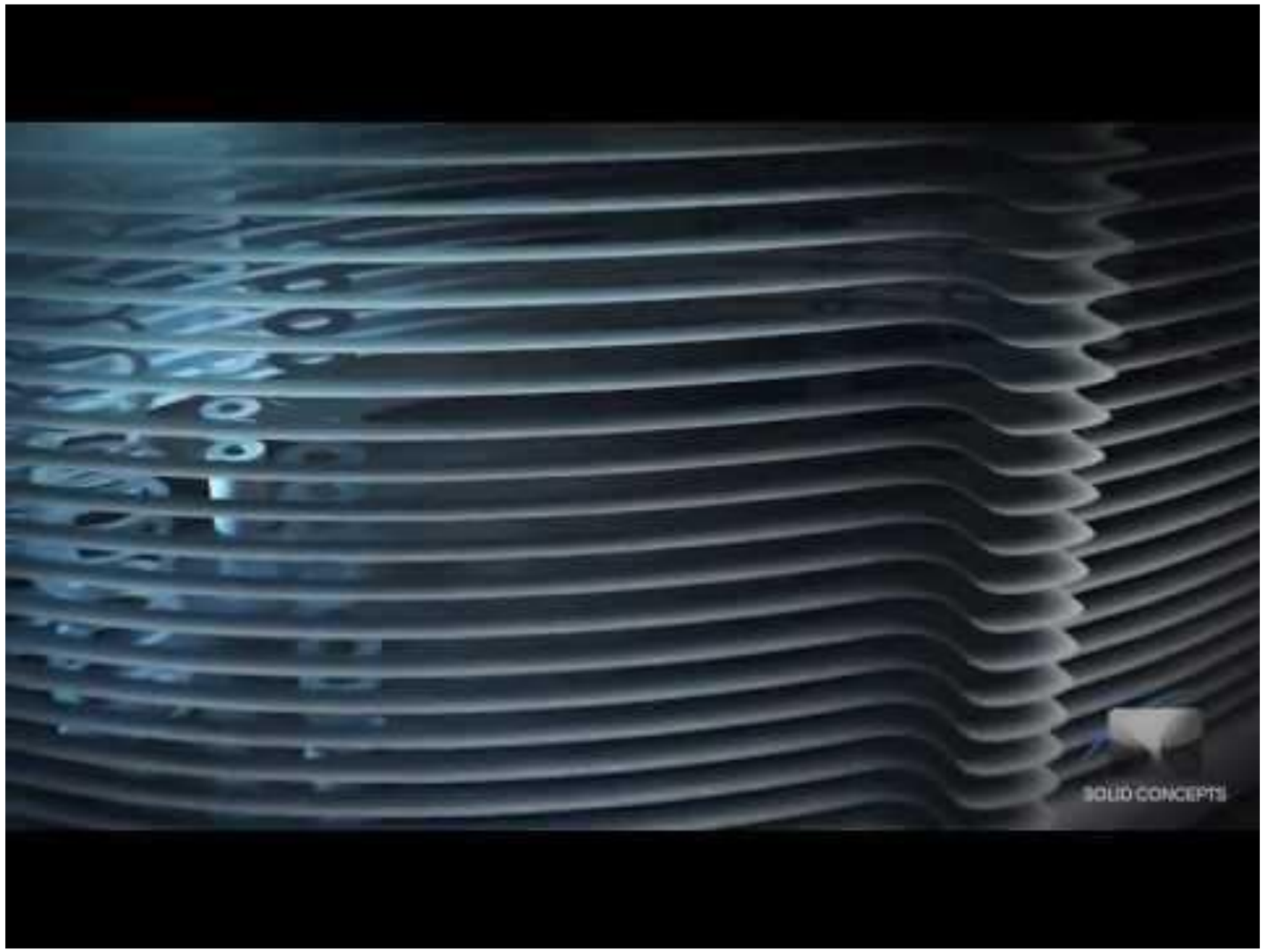
Pro:

1. Very Accurate
2. Durable and Functional
3. Affordable print cost

Con:

1. Sandy Texture
2. Limited material
3. Machine are expensive $200K

DMLS – Direct Metal Laser Sintering



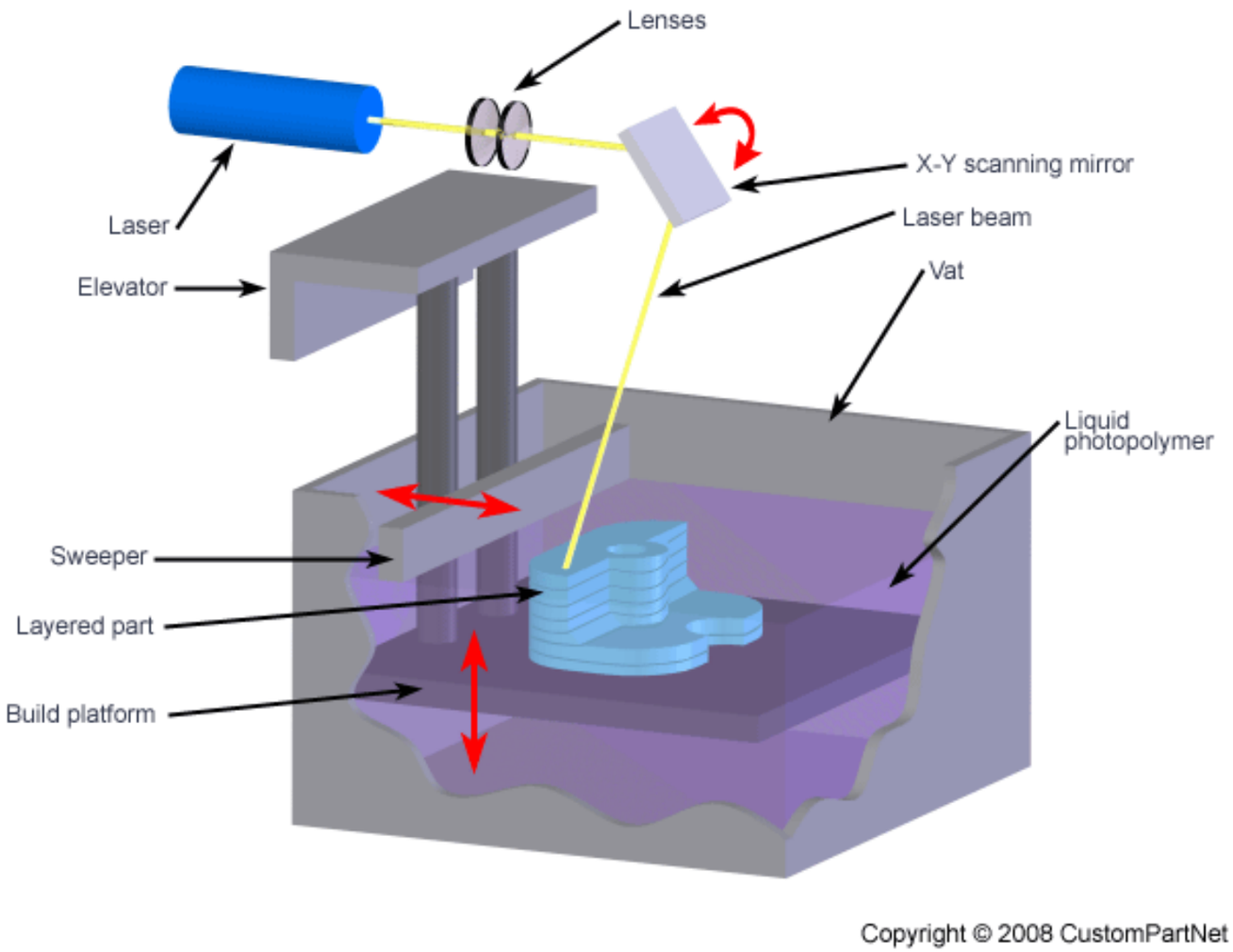
Pro:

1. Direct Metal Printing
2. Durable and Functional

Con:

1. Expensive

SLA



1. Heat plastic filament
2. Extrude liquid plastic on the bed
3. Lower the printer bed
4. Repeat the process until done
5. Remove Support Material

SLA

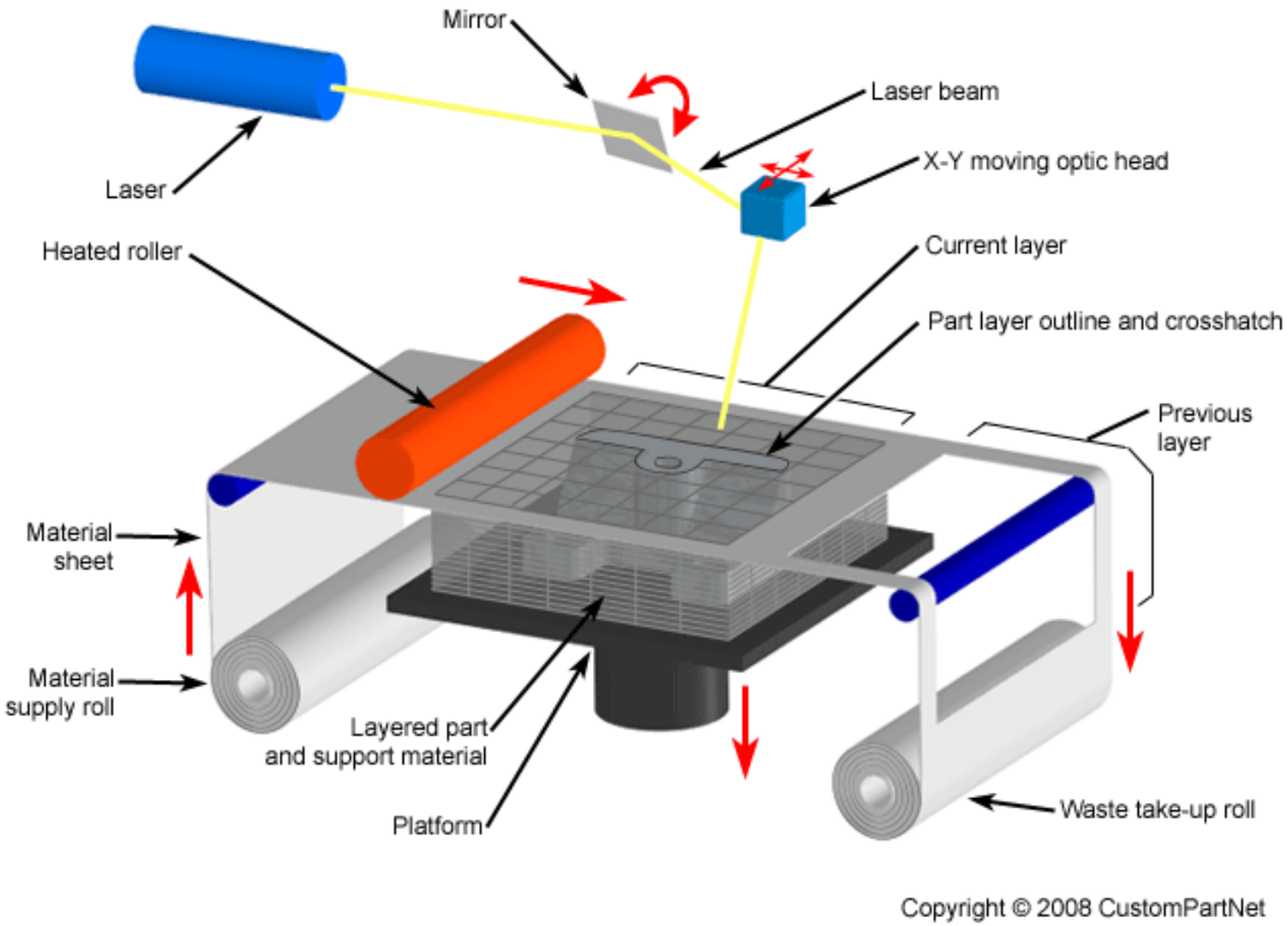
Pro:

1. Second Most Popular
2. Low cost machine ($2K)
3. High detail

Con:

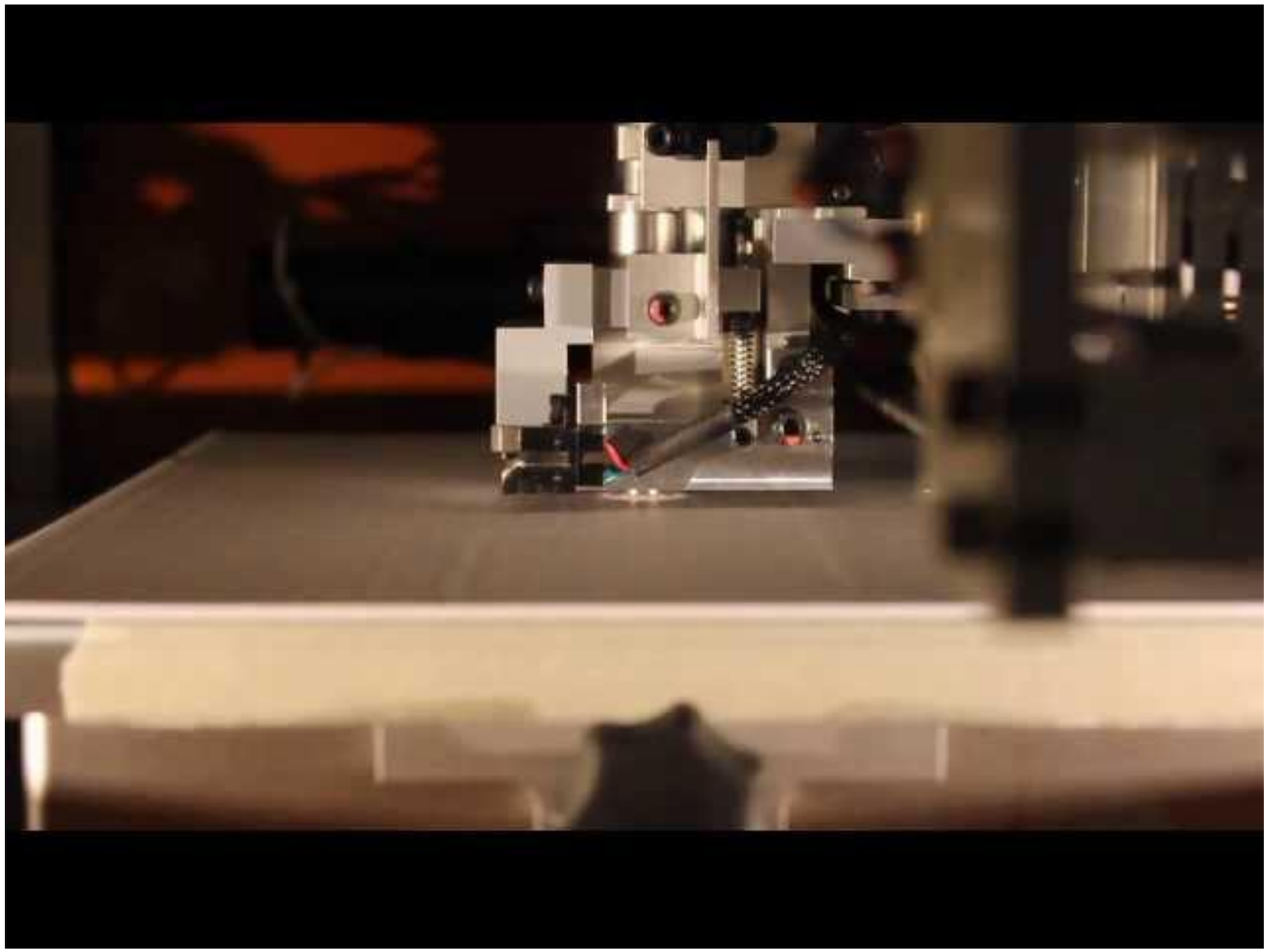
1. Poor Strength
2. Toxic material
3. Limited Color

LOM



1. Apply paper/film on the bed
2. Cut profile by moving knife or Laser
3. Apply Glue on the cutted area
4. Add one more layer on top
5. Repeat process

LOM



http://www.youtube.com/watch?v=GVzRyKxD6Zc

Pro:

1. Can print in color
2. Cheap printing material(paper)

Con:

1. Limited geometry
2. Poor finish
3. Waste a lot of paper
4. Expensive $50K

http://cs599.hao-li.com

Thanks!