Autodesk Is to Additive Manufacturing as Stratocaster Is to "Stairway to Heaven"

Dave Gleason

Software Manager - Optomec Inc.

Email: dgleason@optomec.com

Intro

Dave Gleason, Software Manager, Optomec, Inc.

Who am I?

- 14 years of experience at Optomec
- Expert in Optomec additive-manufacturing
- Fiercely passionate about what I do
- Love to enjoy my family and ride, hike, climb

What does Optomec make?

- We make additive-manufacturing systems (Industrial 3d printers).
- Products target a wide range of applications but include high value part repair to printed electronics.

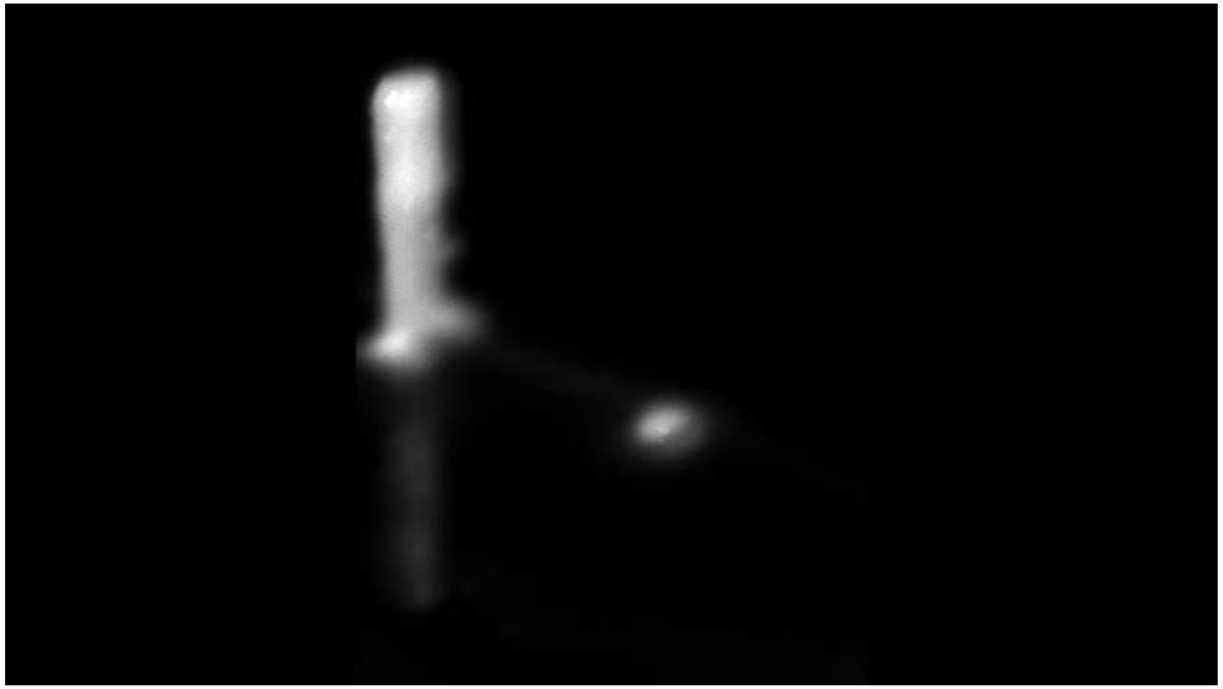
Key learning objectives

At the end of this class, you will be able to:

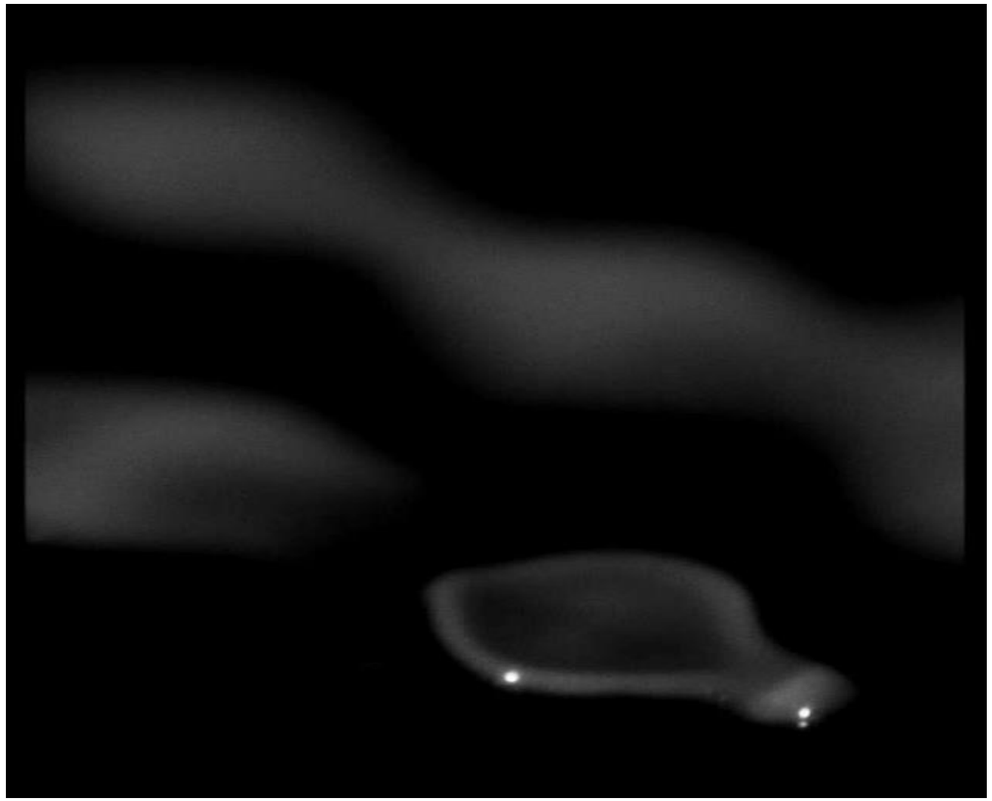
- Visualize opportunities for Autodesk product use for additive manufacturing
- Understand some key differences between additive and subtractive manufacturing

Section 1 Optomec Additive Manufacturing

Video - Printing with UV cure

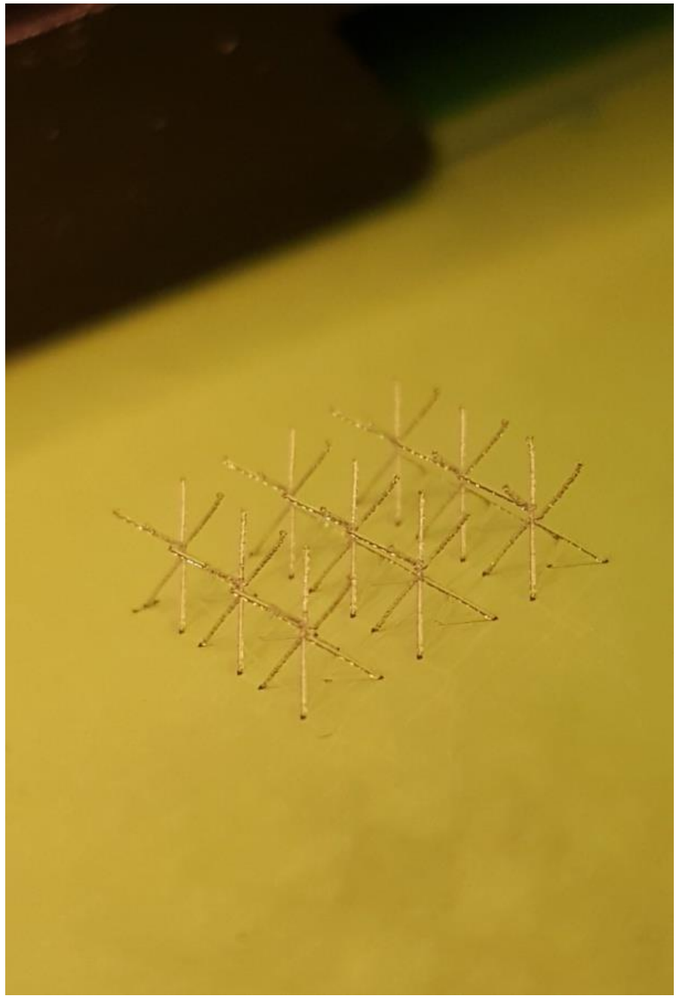


Printing **with** UV Illumination



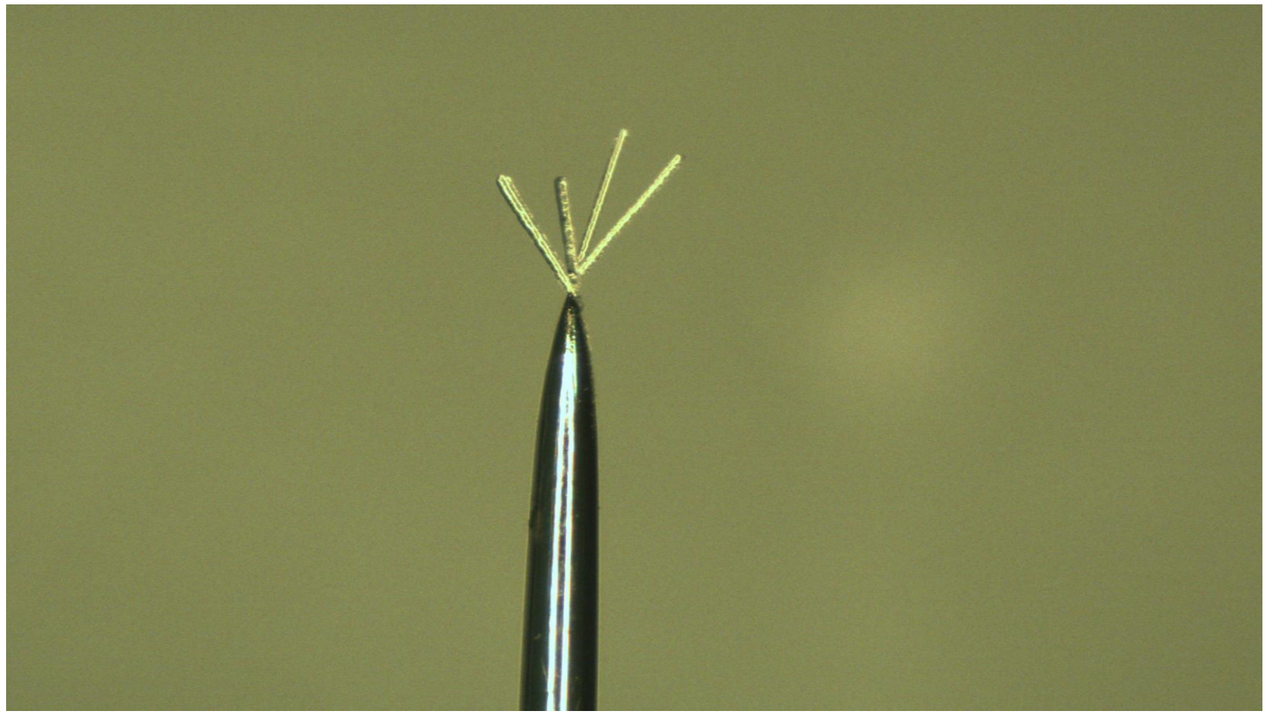
Printing **without** UV Illumination

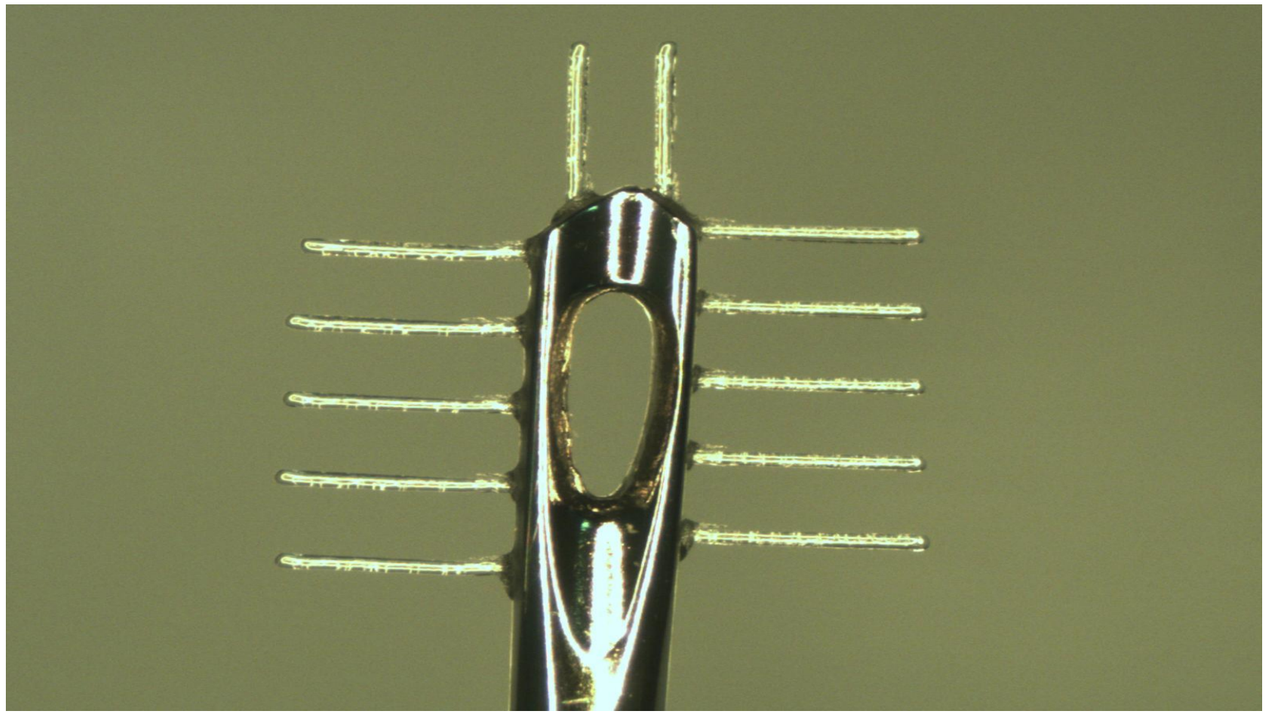
Two-Layer Free Standing Structures



- Layers printed with x-,y- translation outwards from vertex.
- Z-axis raised 2 mm for second layer

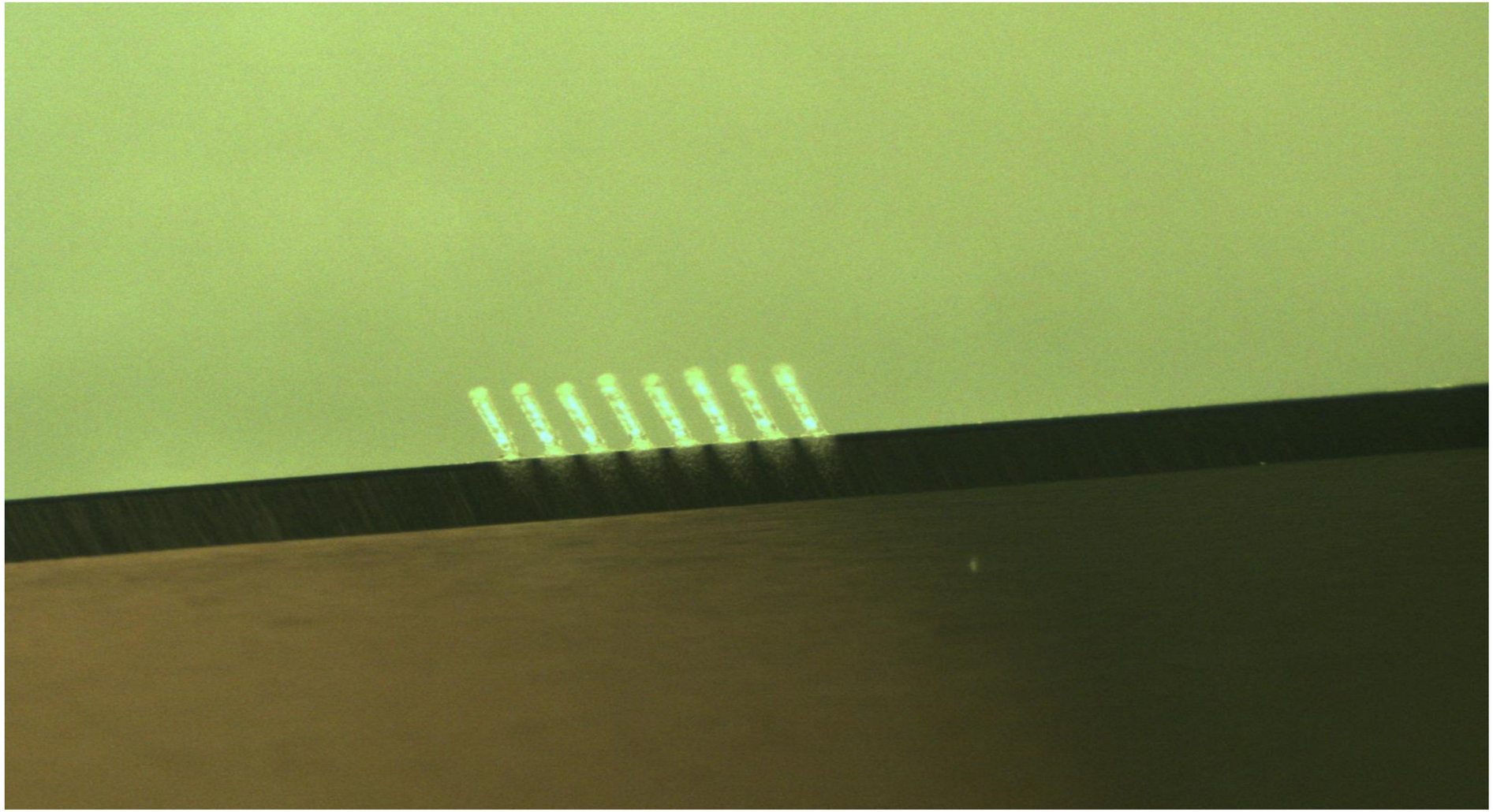
Making a Point





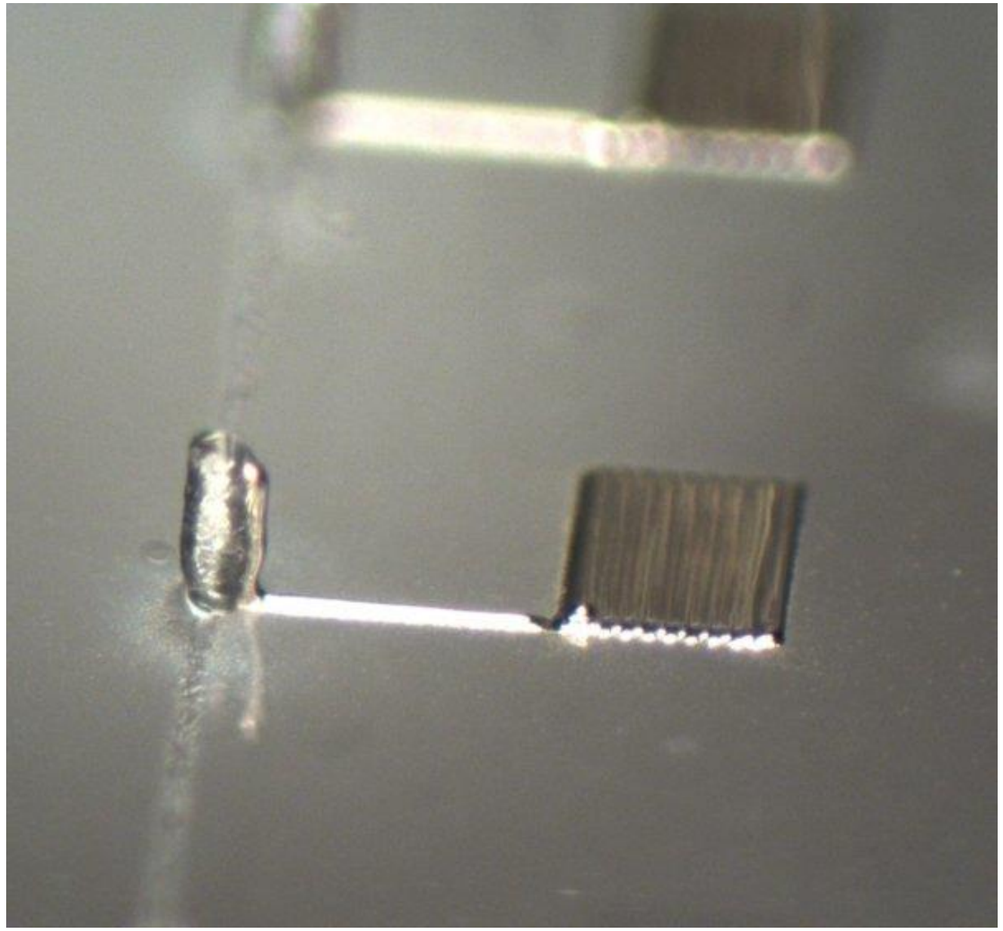
Acrylic posts on the point of a needle

The Cutting Edge

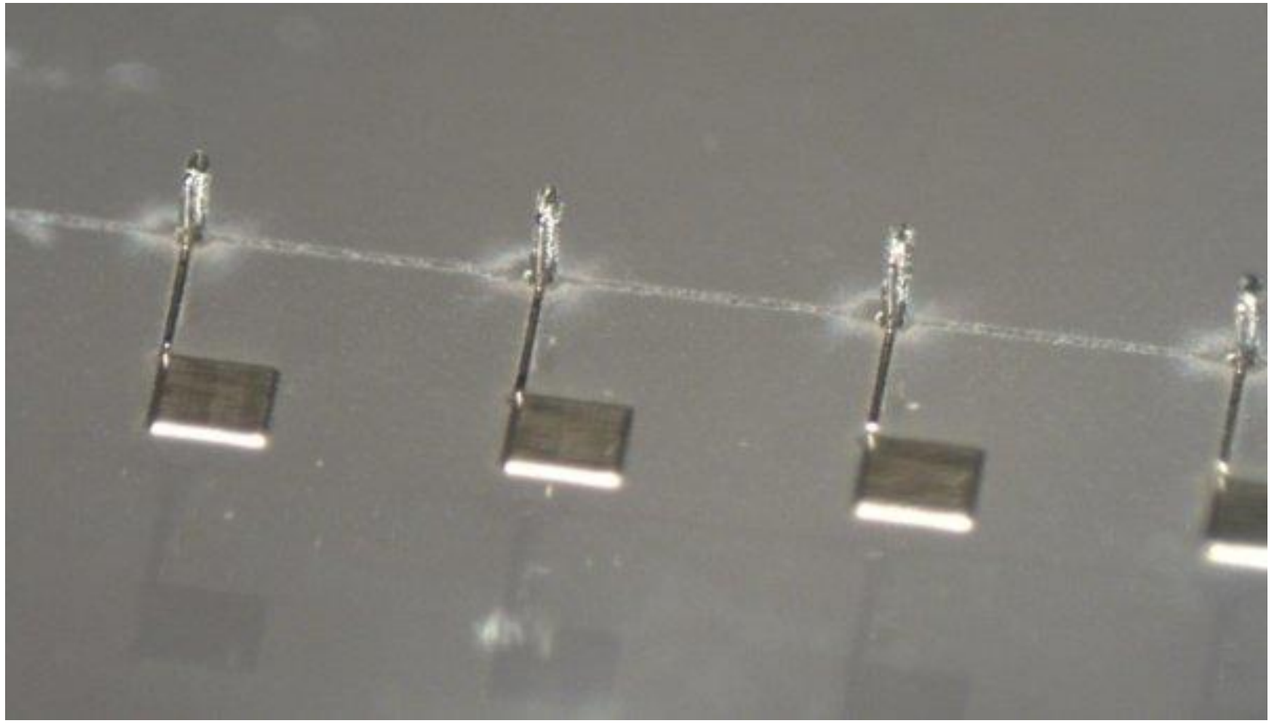


Acrylic posts on the edge of a razor blade

Multi-material



- Acrylic post printed to support 3D dipole antenna

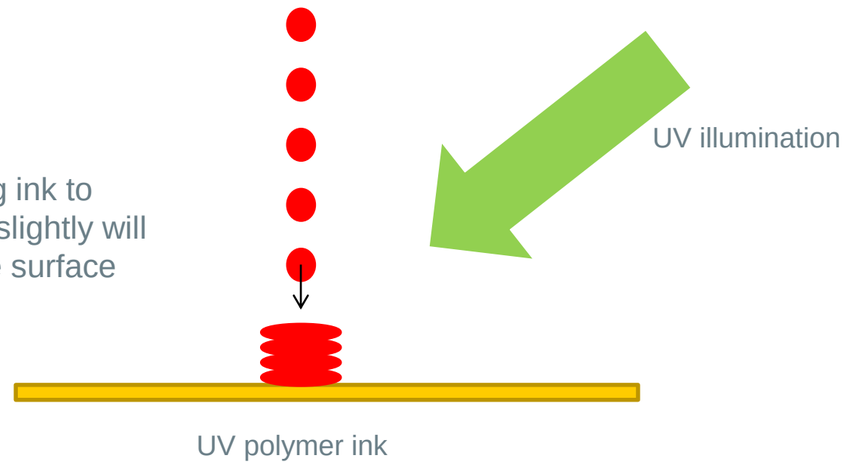


Array of mm-wave antenna with contact pads

Strategies for Printing µ3D structures

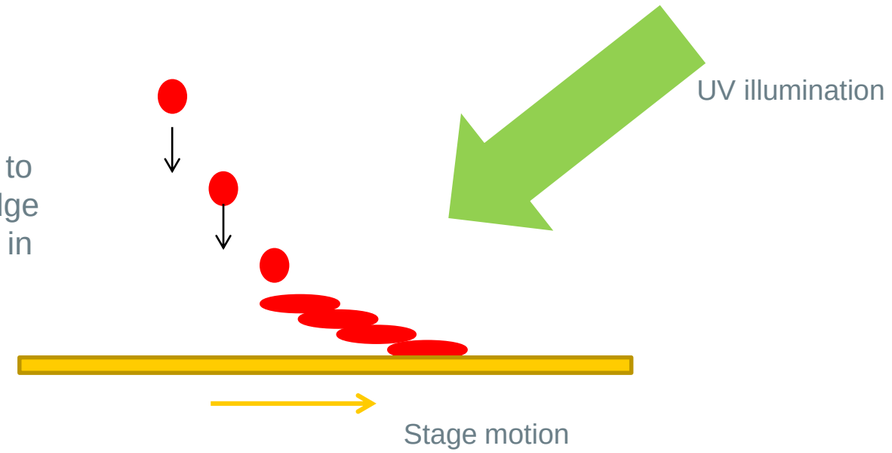
Vertical Build

Allowing ink to spread slightly will improve surface quality

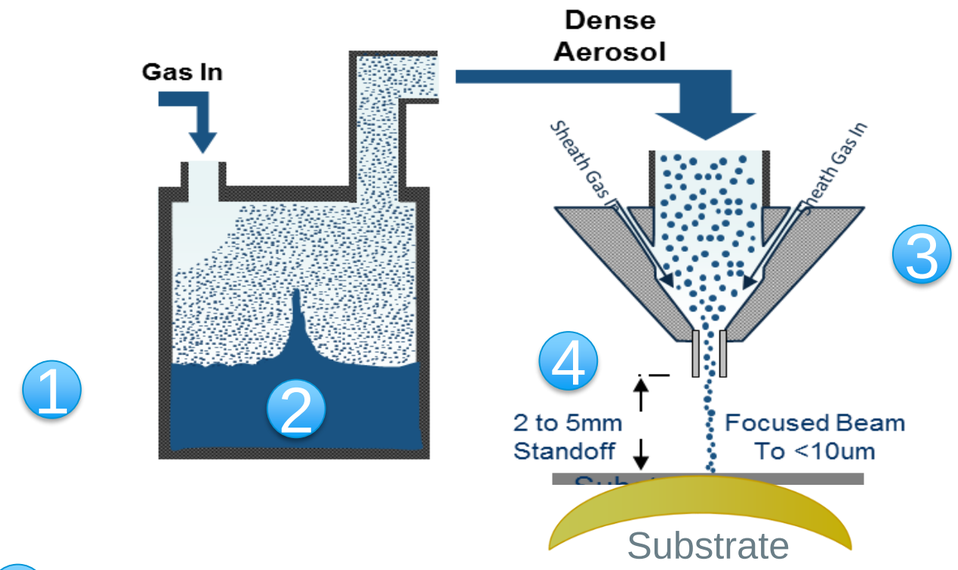


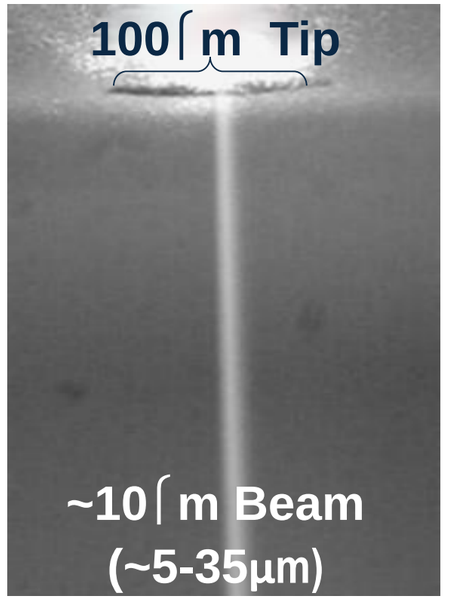
Lateral Build

Ink added to leading edge and cured in place



Printing Liquids (AJ Basics)



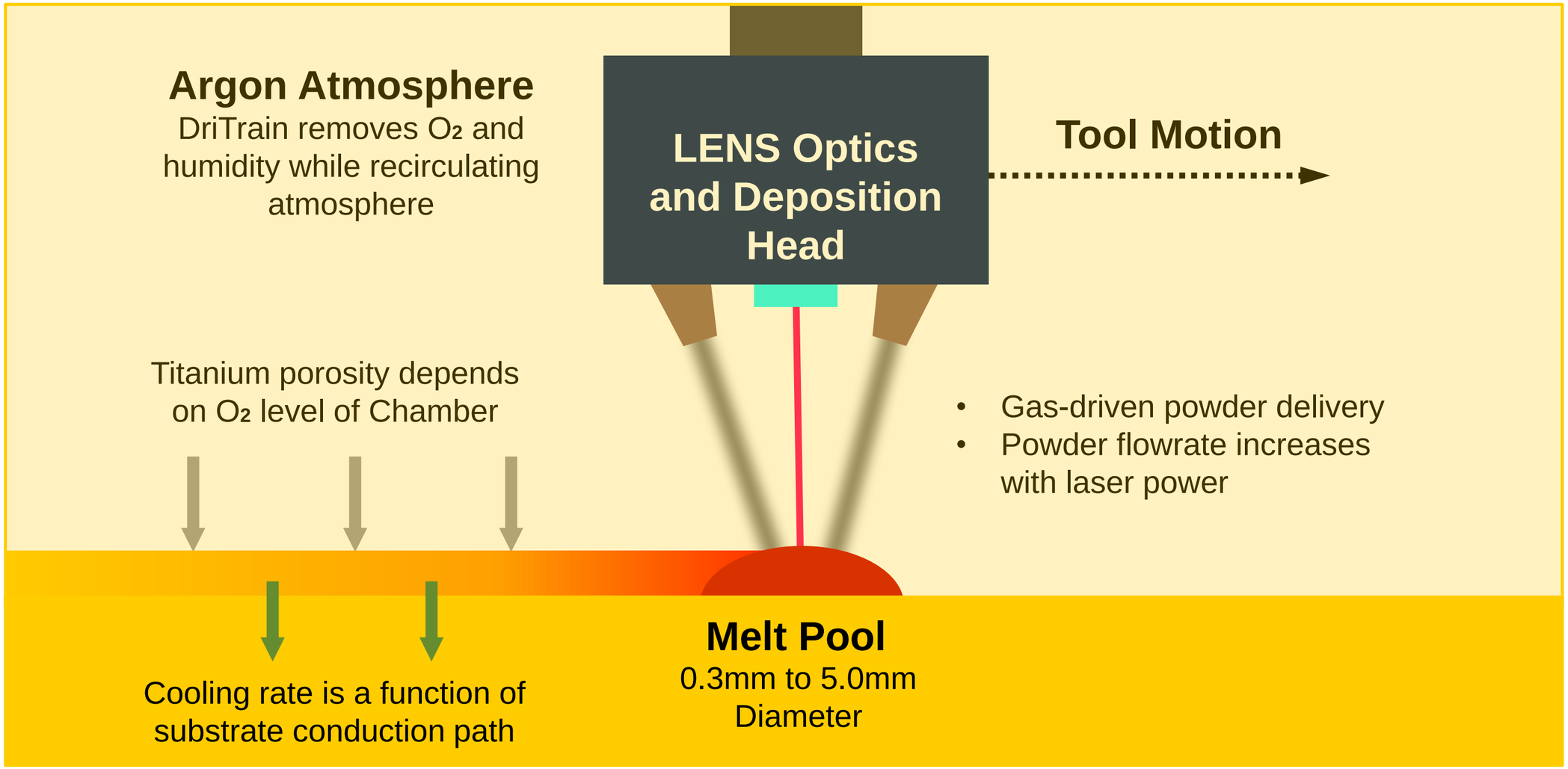


5

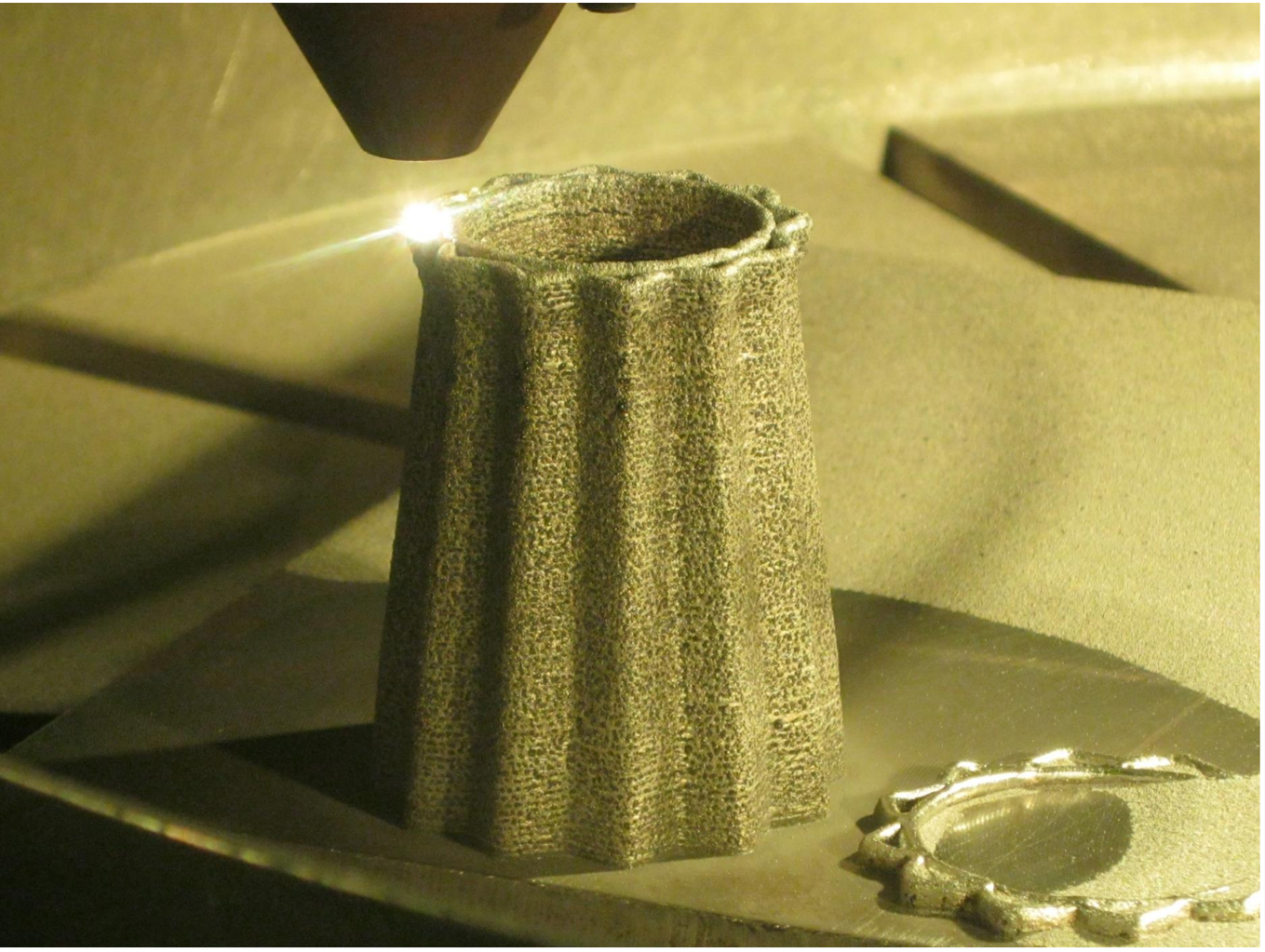
1. Atomize Liquid Electronic Material: conductive inks, dielectric, (1-1,000 cP)
2. Mist of 2 to 5 um Ø highly dense, highly loaded droplets
3. Sheath gas surrounds and focuses particle beam
4. Continuous Flow Exits at 50m/s remains collimated for up to 5 mm
5. Print on planar and non planar substrates

Chapter 2 LENS - Technical Basics

Printing powder (LENS basics)



Functional Prototypes and Impossible parts



Optomec additive

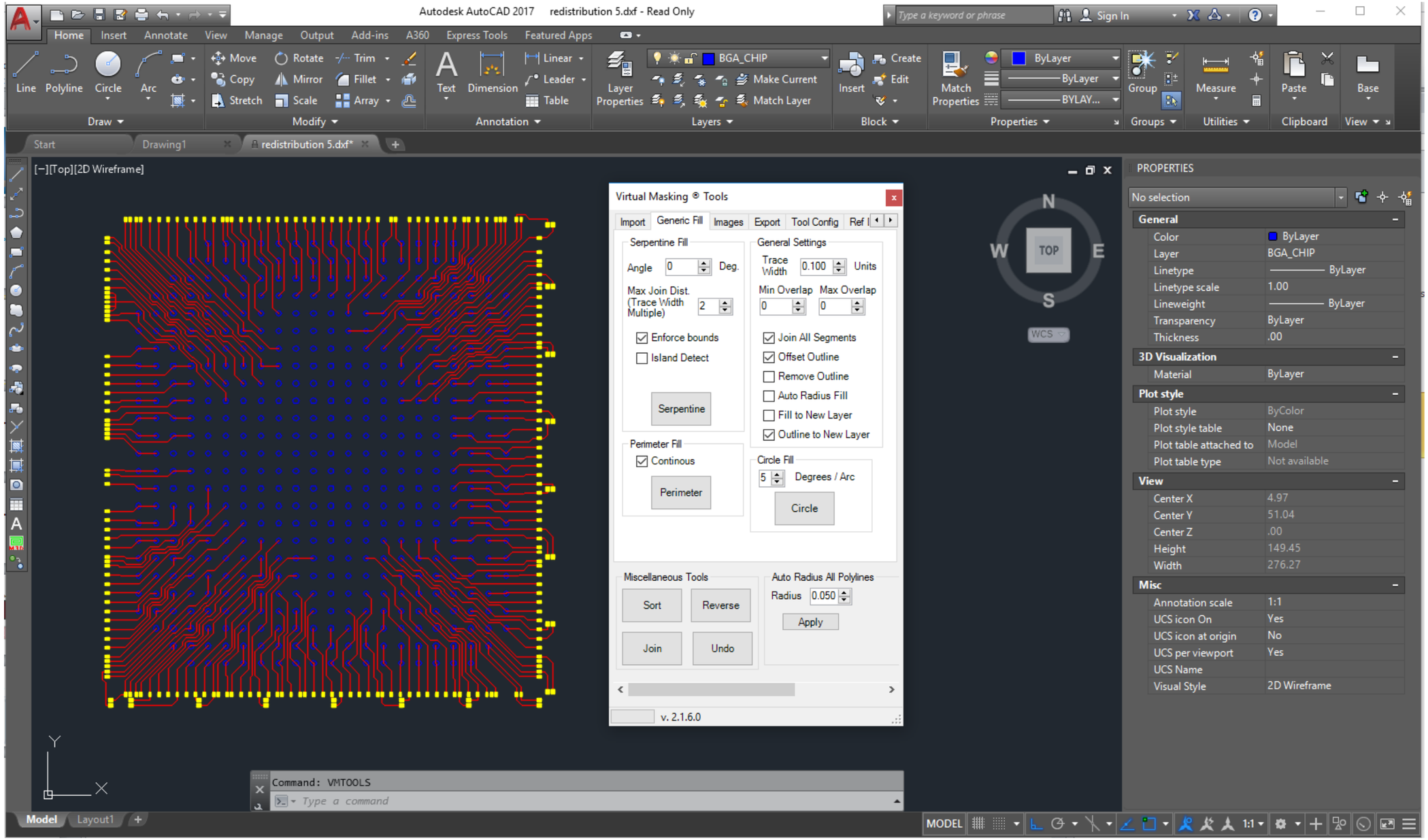
Key differences:

- Make parts that can’t be manufactured any other way!
- Structures are built out of thin air!
- Add features to existing surfaces!
- Blend or layered materials!
- Speed matters (constant velocity is important)
  - Changes in speed effects material thickness and width
- Nearby Features can present challenges
  - Side walls may affect printing by blocking gas flow

Section 2 Art to Part – How do we do it?

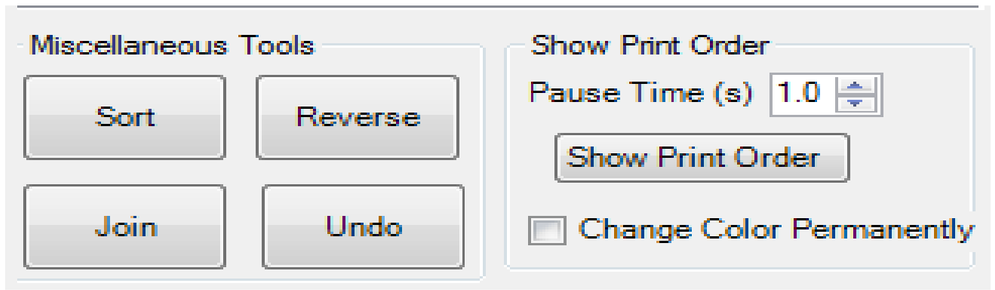
Chapter 1 AutoCad 2017 – 2, 3 axis motion

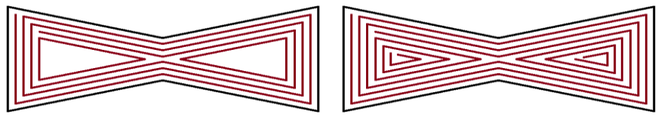
AutoCAD

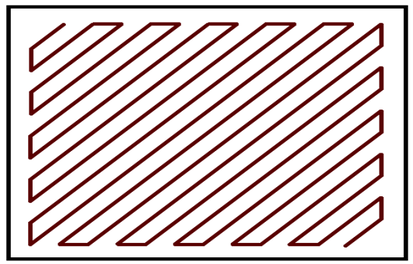

Autodesk AutoCAD 2017 redistribution 5.dxf - Read Only
Home Insert Annotate View Manage Output Add-ins A360 Express Tools Featured Apps
Line Polyline Circle Arc
Move Rotate Trim Copy Mirror Fillet Stretch Scale Array
Text Dimension Linear Leader Table
Layer Properties Make Current Match Layer
BGA_CHIP
Insert Create Edit
Match Properties
ByLayer
Group Measure Paste Base
Draw Modify Annotation Layers Block Properties Groups Utilities Clipboard View
Start Drawing1 redistribution 5.dxf*
[−][Top][2D Wireframe]
Virtual Masking ® Tools
Import Generic Fill Images Export Tool Config Ref
Serpentine Fill
Angle 0 Deg.
Max Join Dist. (Trace Width Multiple) 2
Enforce bounds
Island Detect
Serpentine
General Settings
Trace Width 0.100 Units
Min Overlap 0 Max Overlap 0
Join All Segments
Offset Outline
Remove Outline
Auto Radius Fill
Fill to New Layer
Outline to New Layer
Perimeter Fill
Continous
Perimeter
Circle Fill
5 Degrees / Arc
Circle
Miscellaneous Tools
Sort Reverse Join Undo
Auto Radius All Polylines
Radius 0.050
Apply
v. 2.1.6.0
N W TOP E S
WCS
PROPERTIES
No selection
General
Color ByLayer
Layer BGA_CHIP
Linetype ByLayer
Linetype scale 1.00
Lineweight ByLayer
Transparency ByLayer
Thickness .00
3D Visualization
Material ByLayer
Plot style
Plot style ByColor
Plot style table None
Plot table attached to Model
Plot table type Not available
View
Center X 4.97
Center Y 51.04
Center Z .00
Height 149.45
Width 276.27
Misc
Annotation scale 1:1
UCS icon On Yes
UCS icon at origin No
UCS per viewport Yes
UCS Name
Visual Style 2D Wireframe
Command: VMTOOLS
Type a command
Model Layout1
MODEL

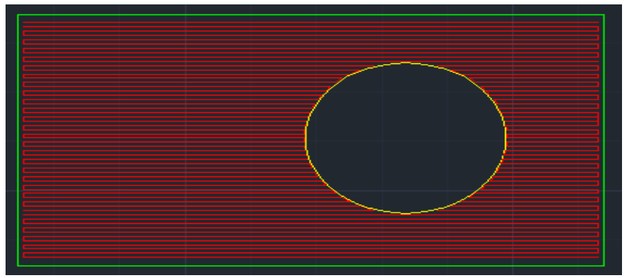
VMTools Filling

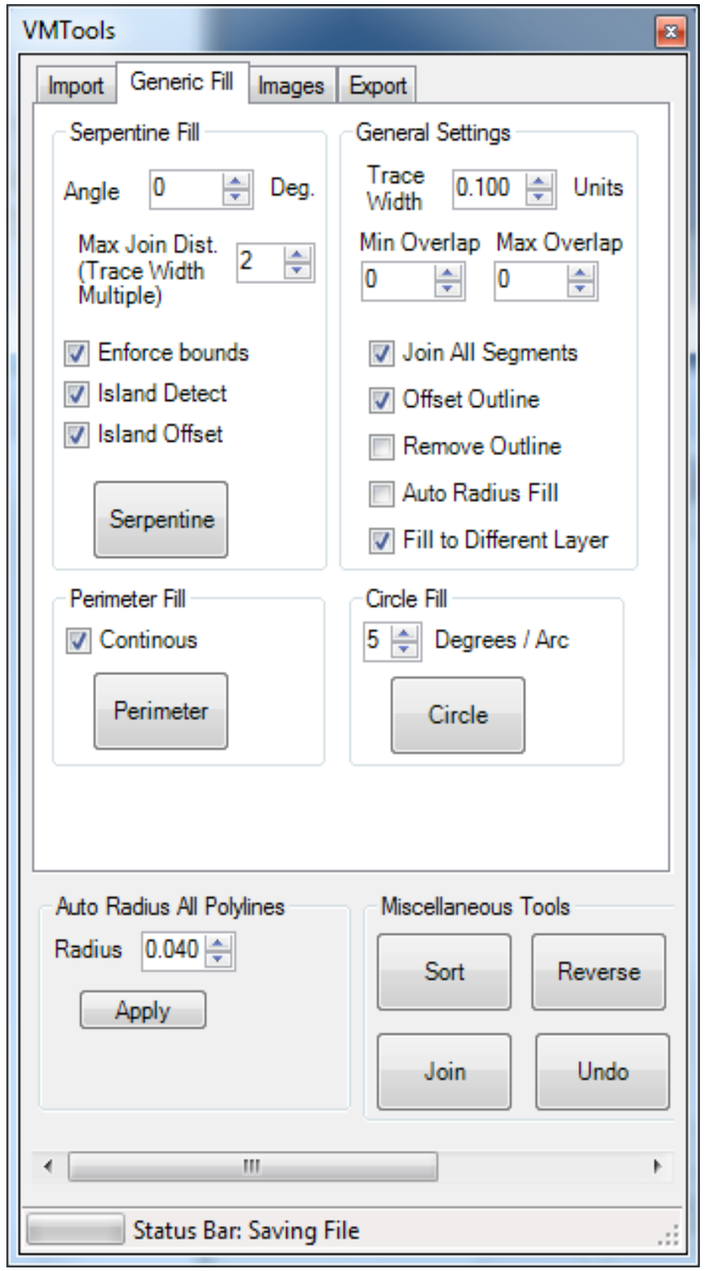
- Supports Serpentine, Perimeter and Circle fills
- Allows users tailor filling to geometry
- Allows users to sort entities
- Provides tools to automatically change geometry











VMTools Export

- Exports dxf entities into ACS motion instructions
- Handles specific motion IO triggers (Shuttering)

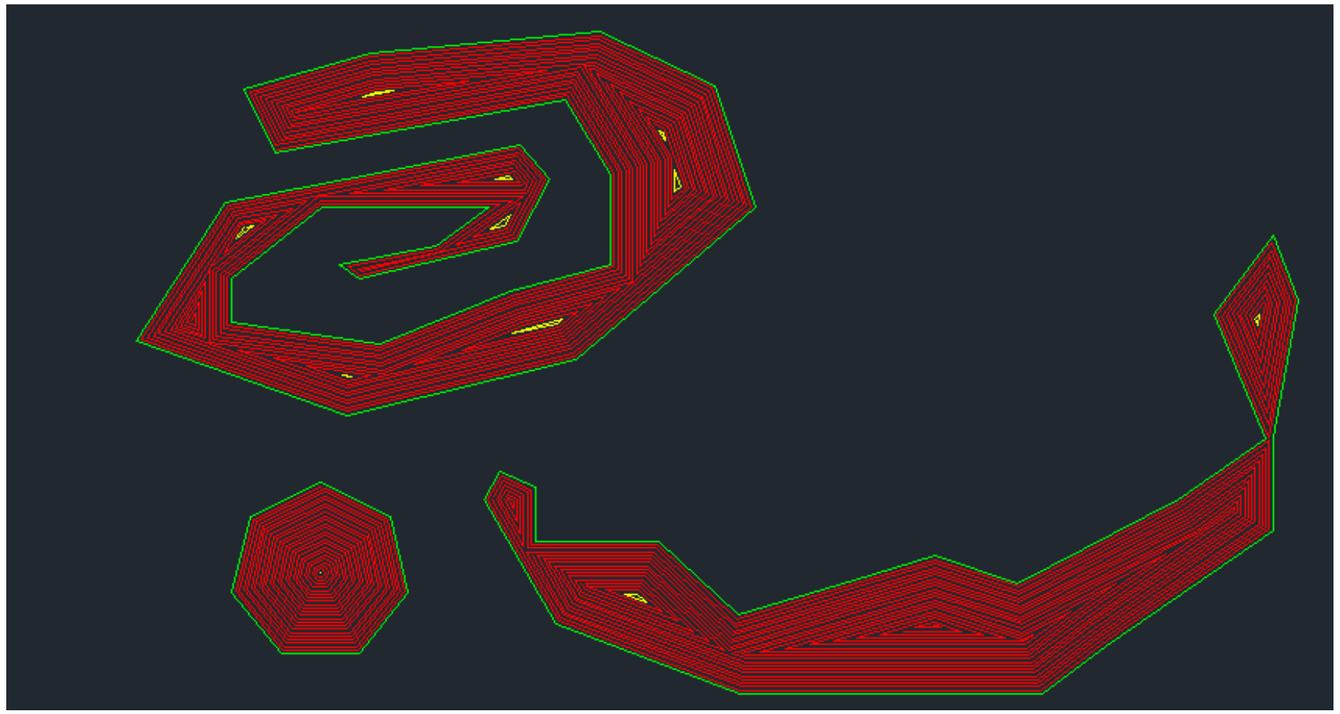
eddie.prg - Notepad

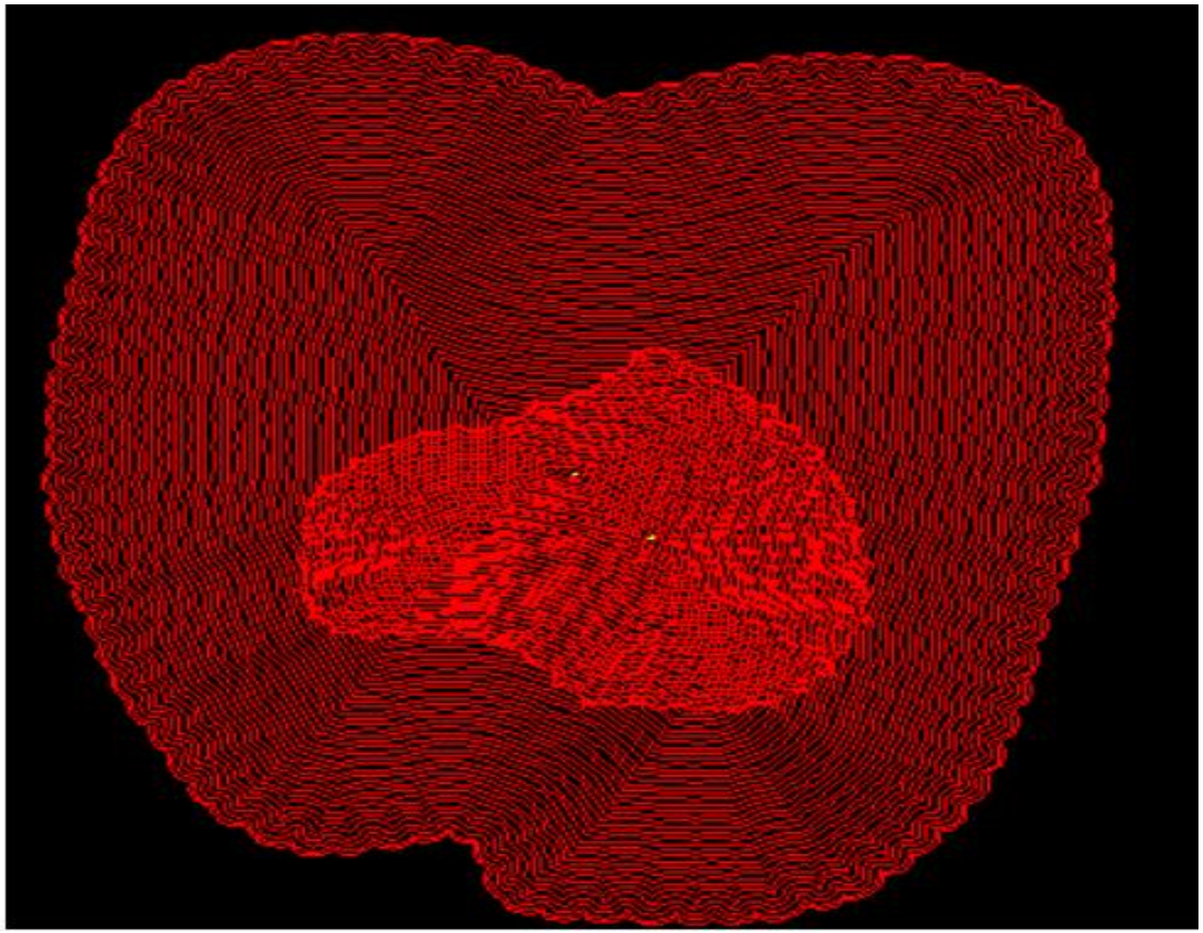
File Edit Format View Help

```
#0
! **********************************
! FID1 0,0
! FID  END
! Generated by: C:\Users\dgleason.OPTOMEC\Desktop\Toolpaths\Manufacturing Test Toolpath-2 non zero fid.dxf
! Axes: XYZTR=XYZ
! C:\Users\dgleason.OPTOMEC\Desktop\Toolpaths\Manufacturing Test Toolpath-2 non zero fid.dxf
! **********************************

! Declare SOTF Variables
real Accel_Distance, Accel_Time, Accel_Rate
real Shutter_Distance, Open_Shutter_Delay, Close_Shutter_Delay, LeadIn_Distance, LeadIn_Time
real x1, y1, x2, y2, x_LeadIn, y_LeadIn, x_ShutterPos, y_ShutterPos
real slope, intercept, theta

! Set SOTF Variables
Open_Shutter_Delay = 2
Close_Shutter_Delay = 2

ptp/ev (X,Y),2.82350,2.78750,gDblRapidSpeed
x1 = 2.82350; y1 = 2.78750; x2 = 6.42650; y2 = 2.78750; Call Calculate_LeadIn
MSEG (X,Y),2.82350,2.78750
line (X,Y),6.42650,2.78750
arc2 (X,Y),6.42650,2.82350,1.57080
line (X,Y),6.46250,6.42650
arc2 (X,Y),6.42650,6.42650,1.57080
line (X,Y),2.82350,6.46250
arc2 (X,Y),2.82350,6.42650,1.57080
line (X,Y),2.78750,2.82350
arc2 (X,Y),2.82350,2.82350,1.57080
ENDS (X,Y)
wait LeadIn_Time
till (GRTIME(0)<=Close_Shutter_Delay) & (GRTIME(1)<=Close_Shutter_Delay)
OUT0.1=0
till (^X_AST.#MOVE) & (^Y_AST.#MOVE)
!Feature 1
```

Ln 1, Col 1

For fun!



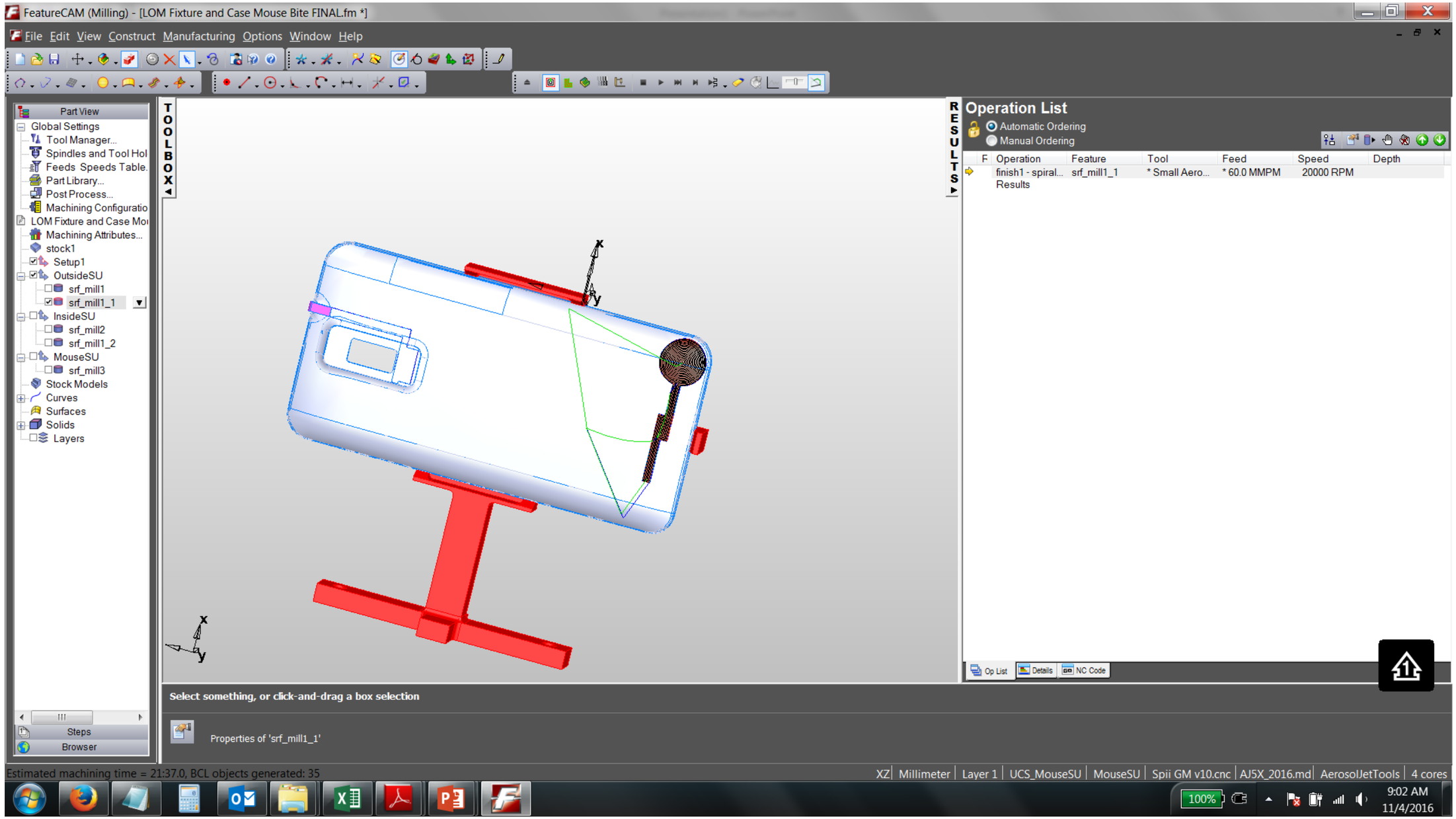


Workflow for 3+2 (Non-coordinated 5 axis)

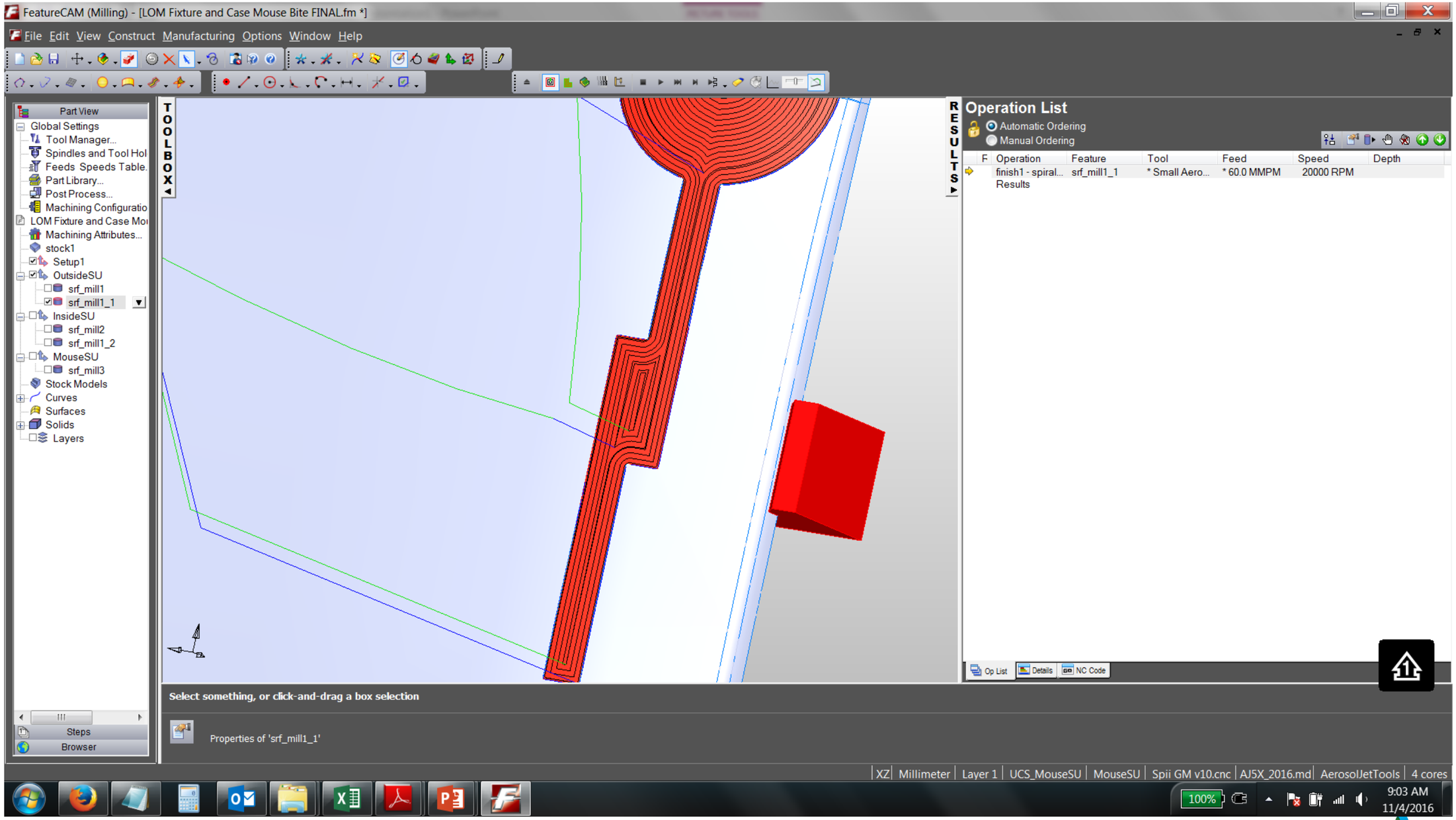
- **Import Solid model** using ACAD import (STEP or IGES)
- **Explode model**
- **Delete the solid portion**, leaving just the surface antenna pattern.
- Use Gizmo tool to **orient** the surface so we are looking down on the surface to be printed.
- Use **Flatshot** command to project this orientation. Check Hide lines and save to a new file.
- **Open 2D file**. Make a new active layer called printed.
- **Use 2d polyline** tool to generate perimeter line around the antenna shape. Avoid getting too close to the edges of the part where there is high curvature. Might need some design rules here.
- **Close the polyline**, if necessary , with Join. Now we can use VMTools or other 2d software tools for filling.
- My preference is to use **Offset** first. I offset the first line by approximately ½ line width. Subsequent lines are offset by about ¾ line width so we get enough overlap. Then **explode** the lines. **Join** where needed to generate a continuous line. Use Joint to reform the polyline. It may take an iteration or two to get all the lines back together. Don't forget to **erase** the original perimeter line.
- **Manually edit the ends** of the polylines so that the shutter points do not potentially short neighboring areas.
- **Manually add more raster lines** in critical areas, such as vias or contact pads. More material will be printed in those locations.
- **Save file** and / or post it to ACS format.
- **Manually edit file** to include shutter open and close times.
- **Repeat procedure** for other orientations (eg. Top, side, and bottom).

Chapter 2 FeatureCAM - 5 axis motion

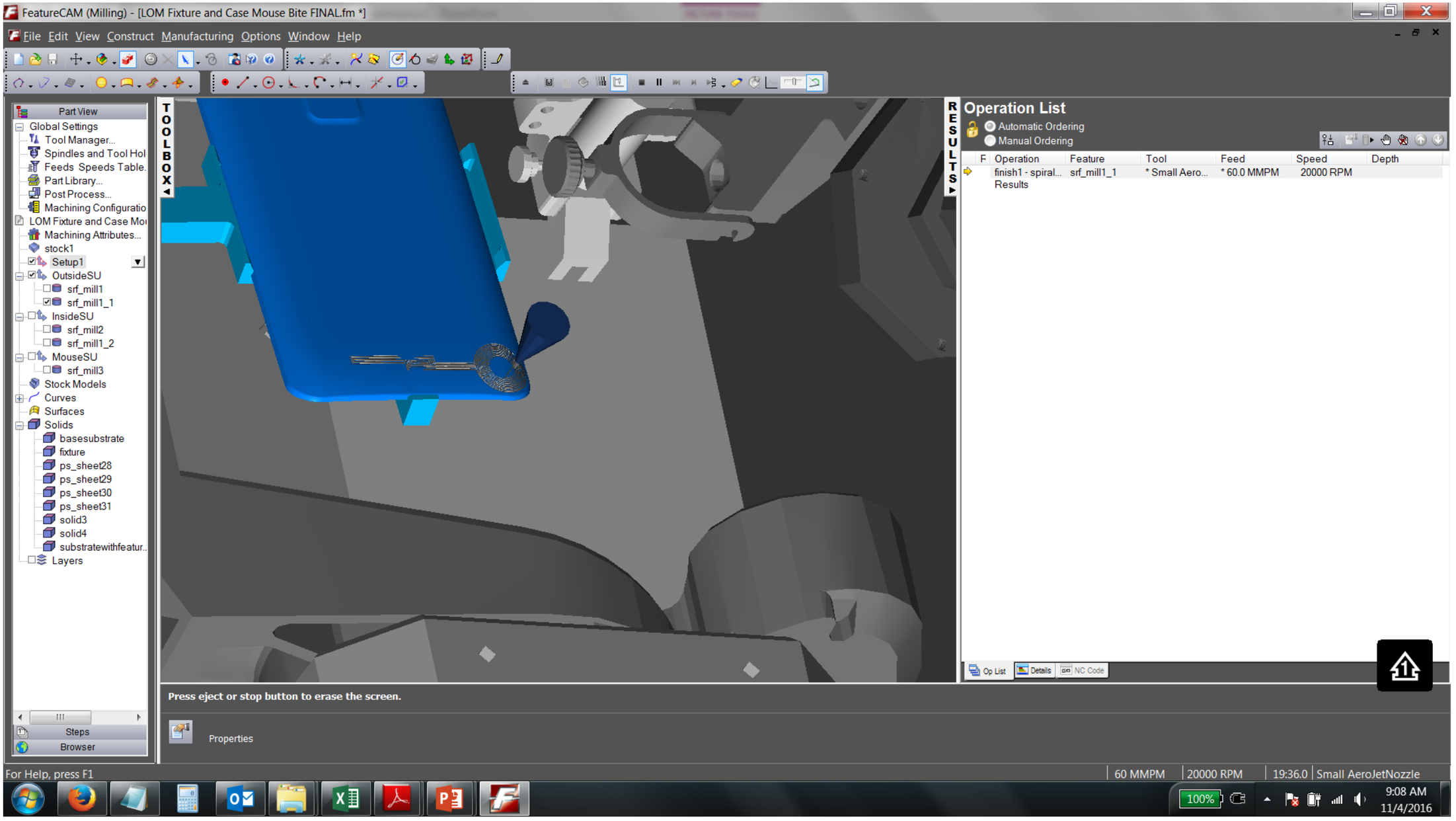
5 Axis motion!



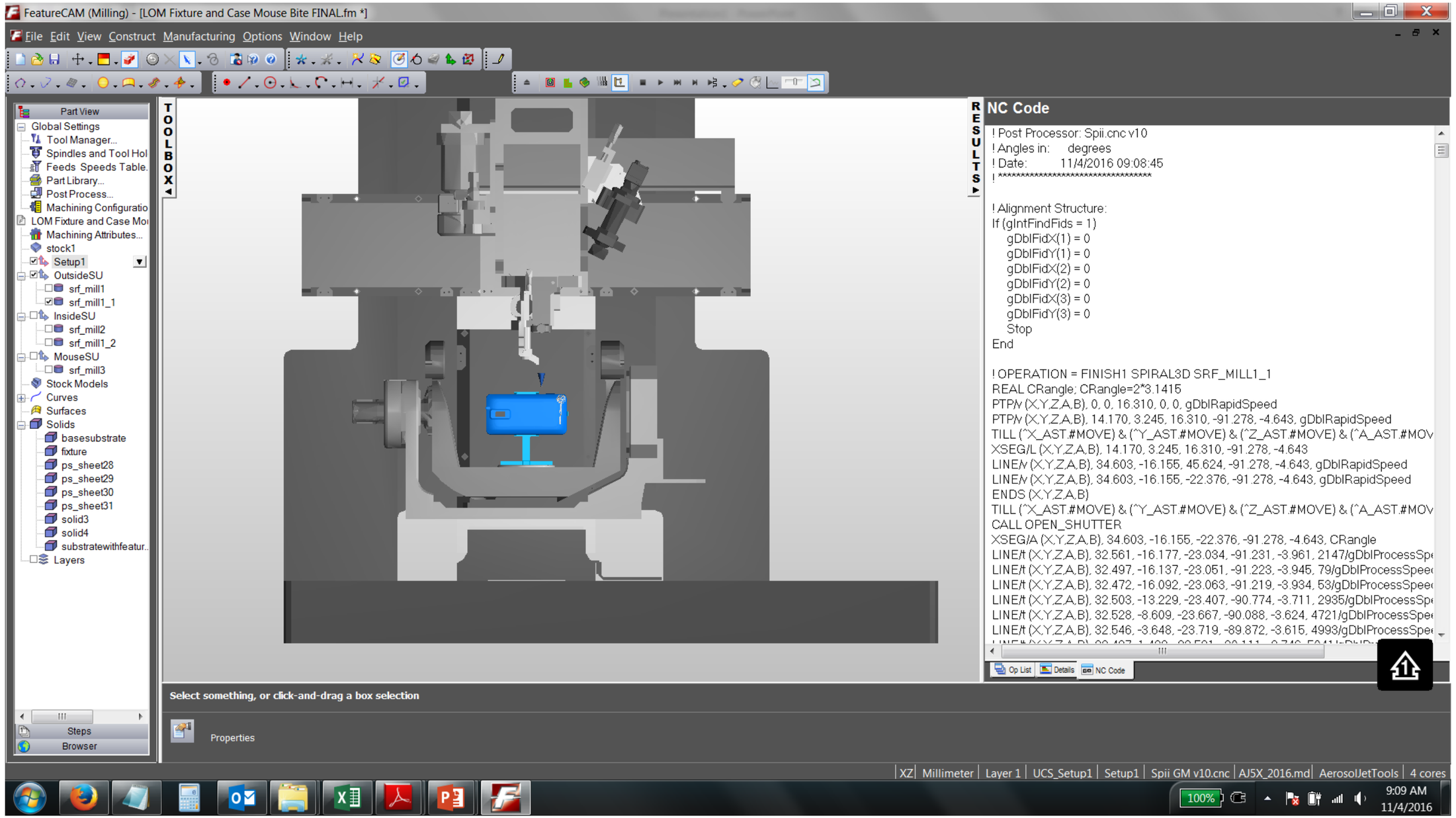
Print projected on curved surface



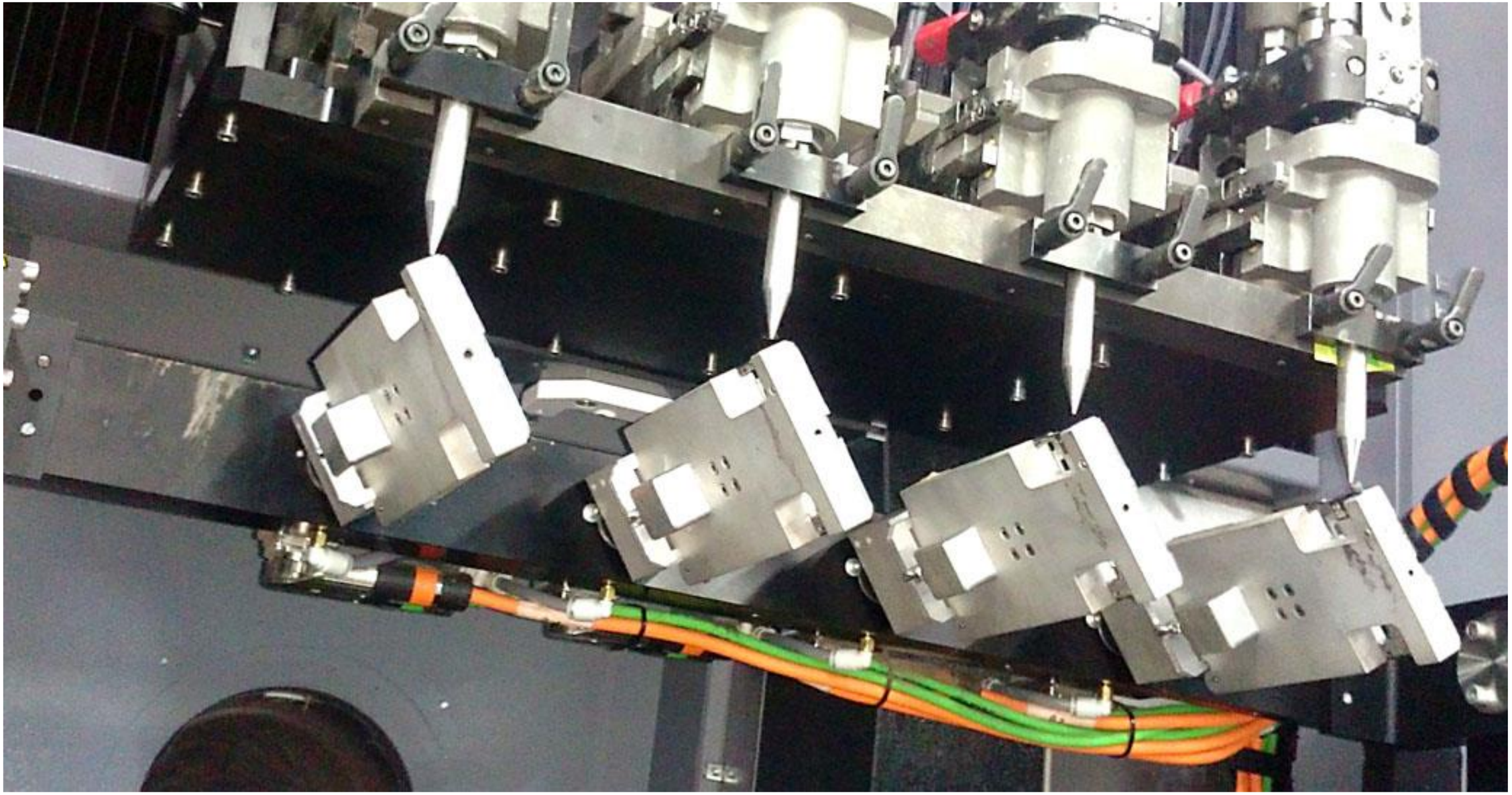
Simulation to evaluate and detect collisions!



Job complete!



Scale to production!



Summary in five

1. Additive-manufacturing is different, but the boundary is your imagination
2. Optomec makes the best additive tools on the planet
3. Autodesk is key to Optomec success
4. You want the best, go get it!
5. Autodesk Is to Additive Manufacturing as Stratocaster Is to "Stairway to Heaven"

Acknowledgements

AutoCAD 2017
FeatureCAM 2014

Optomec management
- AJ Product Mgr. Mike O'Reilly
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- Dr. David Sessoms

Optomec LENS
- Op Mgr. Amy Anderson
- ME Zach Stevens
- Application Engineer Himanshu Sahasrabudhe

Led Zeppelin – "Stairway to Heaven"

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