CASE STUDY

Combining Post-Processing Techniques to Achieve the Optimum Surface Finish

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CHALLENGE

The surface roughness of 3D printed parts is considered a constraint for many end use applications. In general, achieving the desired result involves a combination of various processing techniques.

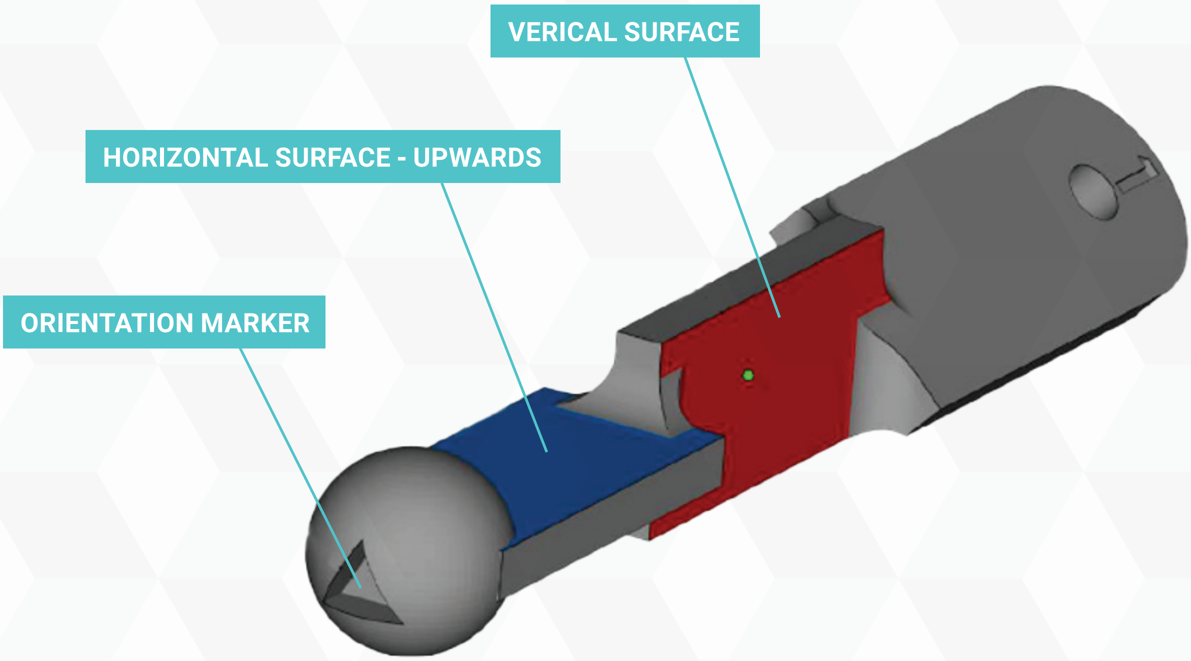
This study analyzes multiple processes, including De-Powdering, Shot Blasting, Chemical Vapor Smoothing, Centrifugal Mass Tumbling and Colouring in different combinations. The aim is to evaluate the effectiveness of various post-processing combinations on the end result, i.e. on the magnitude of surface smoothness of 3D printed parts.

OVERVIEW

Additive Manufacturing Technologies (AMT Ltd.) in cooperation with ERPRO 3D Factory seek to analyze not only the combination of several post-processing steps but also the different surfaces in a part depending on the printing direction. In order to do so, parts were printed using Multi Jet Fusion (MJF) and Selective Laser Sintering (SLS) technologies using PA11 material. These were further divided into subgroups and the same steps were applied to each group. Three surface roughness measurements and microscopic images were made before and after each step.

THE SAMPLE PARTS

The parts were designed in such way that each sample part has multiple flat surfaces with different orientations within the build. By taking the triangle on the extremity of the sphere, it is possible to identify the horizontal surface – facing upwards - as well as a vertical or side surface.



METHODOLOGY

Nine batches of SLS and MJF samples, each containing a total of five parts, were printed. From these batches, all of the parts were measured after each step for the following tests:

TEST	Steps
1	De-Powdering with glass beads + Vapor Smoothing
2	De-Powdering with glass beads + Shot blasting + Vapor Smoothing
3	De-Powdering with glass beads + Tumbling + Vapor Smoothing
4	De-Powdering with glass beads + Tumbling + Vapor Smoothing + Shot blasting
5	De-Powdering with glass beads + Shot blasting + Vapor Smoothing + Dyeing
6	De-Powdering with glass beads + Vapor Smoothing + Tumbling
7	De-Powdering with Ceramic beads + Vapor Smoothing
8	De-Powdering with Corundum beads + Vapor Smoothing
9	De-Powdering with Stainless Steel beads + Vapor Smoothing

For reference, the terminology for each step is as follows:

- **"De-powdered by AMT"** means that the remaining powder after printing was removed by an automatic PostPro DP PRO system from AMT using glass beads.
- **"De-powdered using another media"** means that the remaining powder after printing was removed on an automatic system from Rösler (AM Solutions) using Corundum, Ceramic or Stainless-Steel blasting media.
- **"Shot blasted"** means that the parts were blasted with coarser glass beads on an automatic PostPro DP PRO system from AMT.
- **"Vapor Smoothed"** means that the parts were processed using the patented PostPro Vapor Smoothing technology from AMT.
- **"Tumbled by ERPRO"** means that the parts were processed on a centrifugal mass-finishing system using abrasive grit particles.
- **"Dyed by AMT"** means that the parts were colored black using dying technology from AMT.

TEST ONE:
DE-POWDERING WITH GLASS BEADS + VAPOR SMOOTHING

MJF

Surface roughness

DE-POWDERED BY AMT

Horizontal surface	Ra 12.1 µm
Vertical surface	Ra 10.9 µm

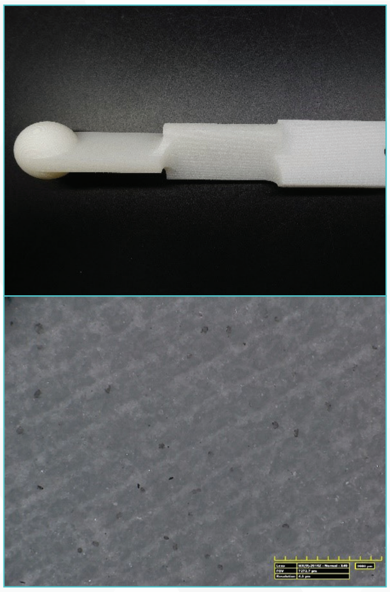
+ VAPOR SMOOTHED BY AMT

Horizontal surface	Ra 2.9 µm
Vertical surface	Ra 2.6 µm

SLS

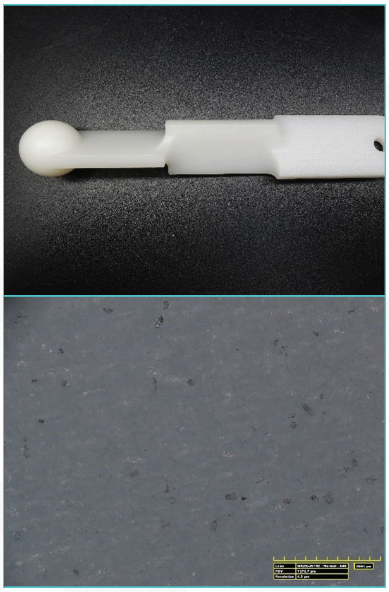
Surface roughness

DE-POWDERED BY AMT



Horizontal surface	Ra 10.1 µm
Vertical surface	Ra 13.4 µm

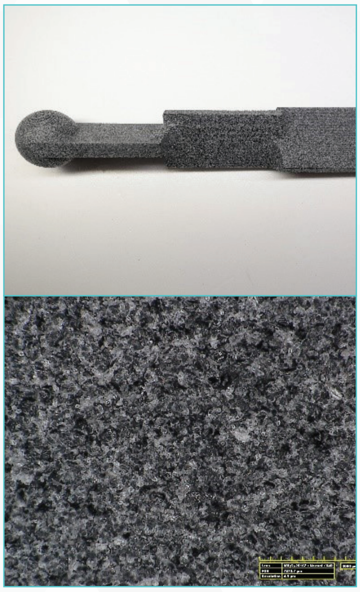
+ VAPOR SMOOTHED BY AMT



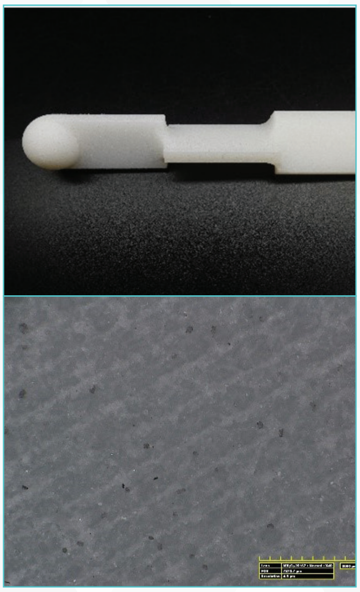
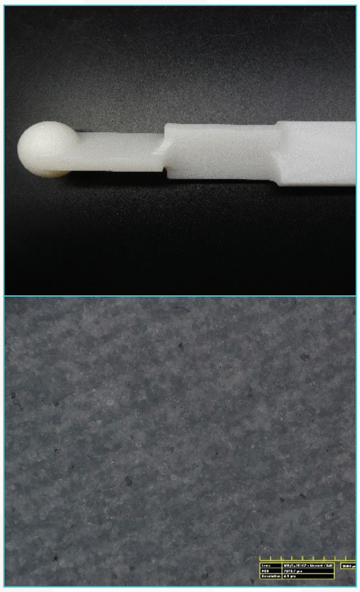
Horizontal surface	Ra 3.3 µm
Vertical surface	Ra 3.7 µm

TEST TWO:
DE-POWDERING WITH GLASS BEADS + SHOT BLASTING + VAPOR SMOOTHING

MJF — Surface roughness

DE-POWDERED BY AMT	+ SHOT BLASTED BY AMT	+ VAPOR SMOOTHED BY AMT
		
Horizontal surface Ra 12.6 µm Vertical surface Ra 11.5 µm	Horizontal surface Ra 10.2 µm Vertical surface Ra 9.3 µm	Horizontal surface Ra 2.7 µm Vertical surface Ra 2.3 µm

SLS — Surface roughness

DE-POWDERED BY AMT	+ SHOT BLASTED BY AMT	+ VAPOR SMOOTHED BY AMT
		
Horizontal surface Ra 9.8 µm Vertical surface Ra 13.6 µm	Horizontal surface Ra 7.4 µm Vertical surface Ra 12.7 µm	Horizontal surface Ra 2.9 µm Vertical surface Ra 3.1 µm

TEST THREE:
DE-POWDERING WITH GLASS BEADS + TUMBLING + VAPOR SMOOTHING

MJF

Surface roughness

DE-POWDERED BY AMT

Horizontal surface	Ra 12.1 µm
Vertical surface	Ra 10.8 µm

+ TUMBLED BY ERPRO

Horizontal surface	Ra 6.5 µm
Vertical surface	Ra 4.9 µm

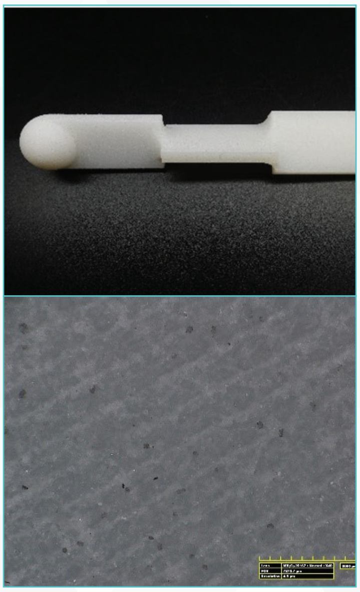
+ VAPOR SMOOTHED BY AMT

Horizontal surface	Ra 2.9 µm
Vertical surface	Ra 2.4 µm

SLS

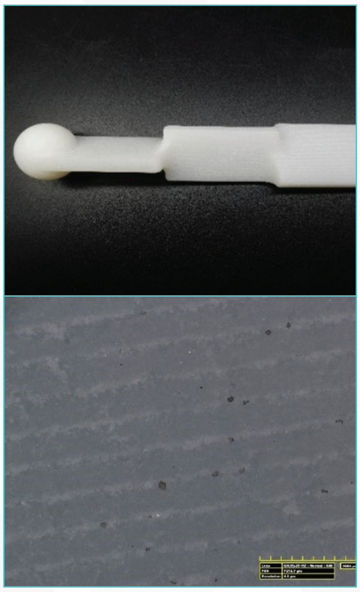
Surface roughness

DE-POWDERED BY AMT



Horizontal surface	Ra 10.7 µm
Vertical surface	Ra 13 µm

+ TUMBLED BY ERPRO



Horizontal surface	Ra 3.8 µm
Vertical surface	Ra 3.9 µm

+ VAPOR SMOOTHED BY AMT

Horizontal surface	Ra 3.1 µm
Vertical surface	Ra 3.2 µm

TEST FOUR:
DE-POWDERING WITH GLASS BEADS + TUMBLING + VAPOR SMOOTHING + SHOT BLASTING

MJF

Surface roughness

DE-POWDERED BY AMT

Horizontal surface	Ra 11.0 µm
Vertical surface	Ra 10.7 µm

+ TUMBLED BY ERPRO

Horizontal surface	Ra 6.5 µm
Vertical surface	Ra 5.4 µm

+ VAPOR SMOOTHED BY AMT

Horizontal surface	Ra 2.6 µm
Vertical surface	Ra 2.3 µm

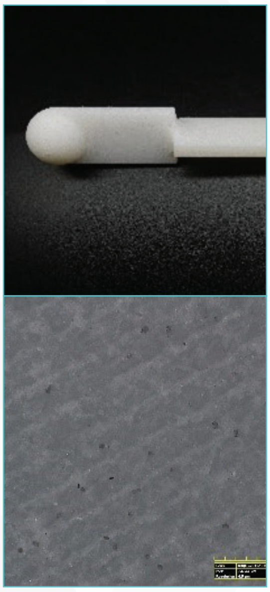
+ SHOT BLASTED BY AMT

Horizontal surface	Ra 2.4 µm
Vertical surface	Ra 1.6 µm

SLS

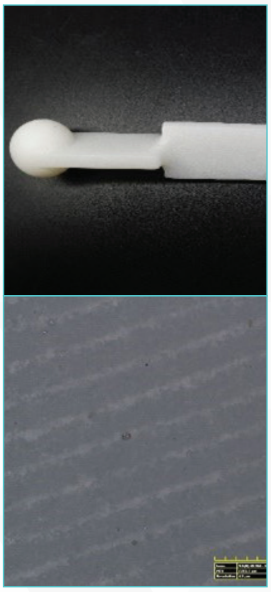
Surface roughness

DE-POWDERED BY AMT



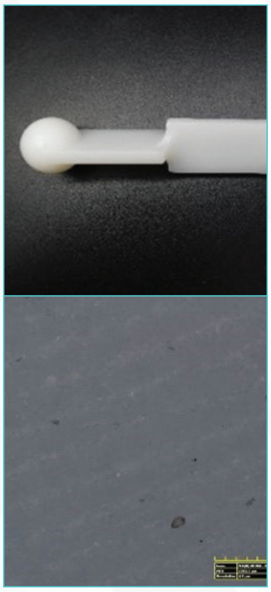
Horizontal surface	Ra 10.7 µm
Vertical surface	Ra 14.1 µm

+ TUMBLED BY ERPRO



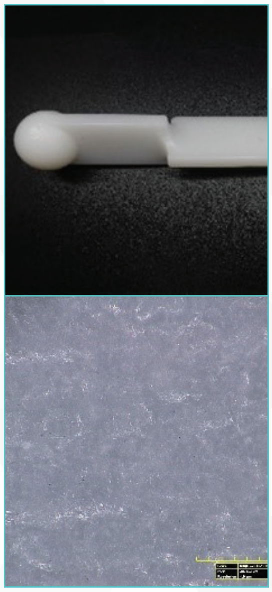
Horizontal surface	Ra 3.7 µm
Vertical surface	Ra 4.1 µm

+ VAPOR SMOOTHED BY AMT



Horizontal surface	Ra 3.0 µm
Vertical surface	Ra 3.2 µm

+ SHOT BLASTED BY AMT



Horizontal surface	Ra 1.8 µm
Vertical surface	Ra 2.5 µm

TEST FIVE:
DE-POWDERING WITH GLASS BEADS + SHOT BLASTING + VAPOR SMOOTHING + DYEING

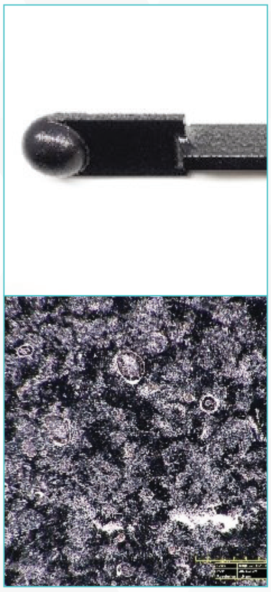
MJF

DE-POWDERED BY AMT

+ SHOT BLASTED BY AMT

+ VAPOR SMOOTHED BY AMT

+ DYED BY AMT

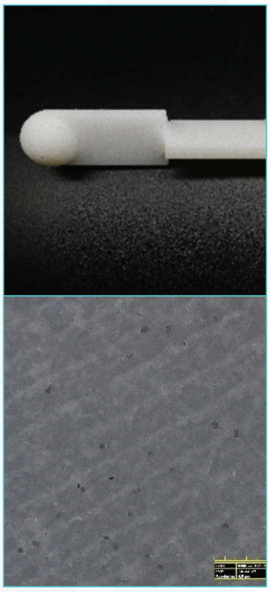


Surface roughness

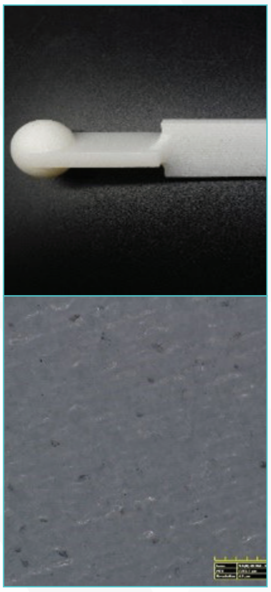
	DE-POWDERED BY AMT	+ SHOT BLASTED BY AMT	+ VAPOR SMOOTHED BY AMT	+ DYED BY AMT
Horizontal surface	Ra 13.0 µm	Ra 9.7 µm	Ra 2.5 µm	-
Vertical surface	Ra 10.5 µm	Ra 8.5 µm	Ra 2.2 µm	-

SLS

DE-POWDERED BY AMT



+ SHOT BLASTED BY AMT



+ VAPOR SMOOTHED BY AMT

+ DYED BY AMT

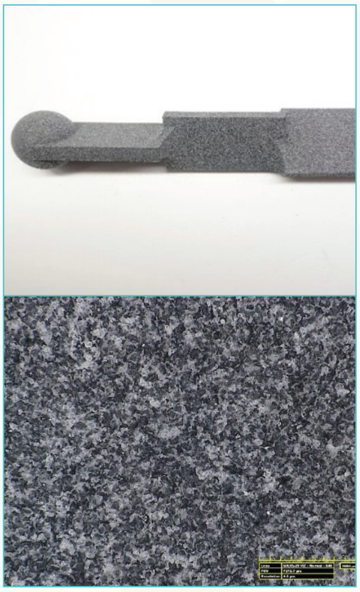
Surface roughness

	DE-POWDERED BY AMT	+ SHOT BLASTED BY AMT	+ VAPOR SMOOTHED BY AMT	+ DYED BY AMT
Horizontal surface	Ra 10.9 µm	Ra 7.3 µm	Ra 3.2 µm	-
Vertical surface	Ra 12.0 µm	Ra 12.9 µm	Ra 3.4 µm	-

TEST SIX:
DE-POWDERING WITH GLASS BEADS + VAPOR SMOOTHING + TUMBLING

MJF

DE-POWDERED BY AMT



Horizontal surface Ra 10.0 µm
Vertical surface Ra 11.5 µm

+ VAPOR SMOOTHED BY AMT

Horizontal surface Ra 2.4 µm
Vertical surface Ra 2.3 µm

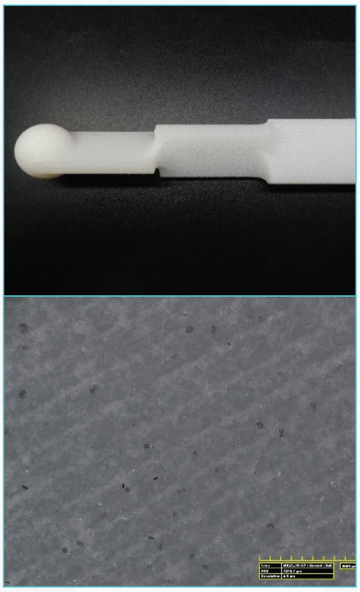
+ TUMBLED BY ERPRO

Horizontal surface Ra 0.9 µm
Vertical surface Ra 1.1 µm

Surface roughness

SLS

DE-POWDERED BY AMT

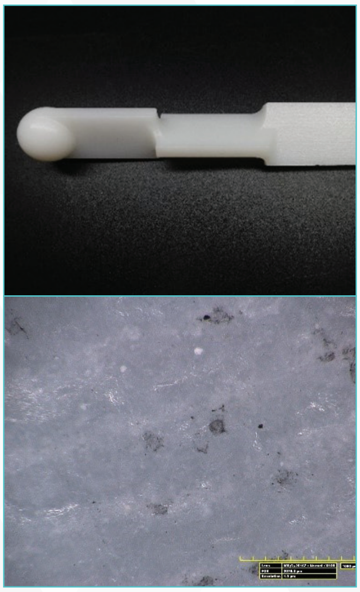


Horizontal surface Ra 10.7 µm
Vertical surface Ra 12.9 µm

+ VAPOR SMOOTHED BY AMT

Horizontal surface Ra 3.1 µm
Vertical surface Ra 3.2 µm

+ TUMBLED BY ERPRO



Horizontal surface Ra 1.5 µm
Vertical surface Ra 1.6 µm

Surface roughness

TEST SEVEN - NINE:
DE-POWDERING USING ANOTHER MEDIA + VAPOR SMOOTHING

The final set of tests all follow the identical methodology, the only difference being that the blasting took place using different media on an automatic system from Rösler (AM Solutions). The three different blasting media which were used are as follows:

- Ceramic
- Corundum
- Stainless Steel

The results for each printing technology are as follows:

MJF

	De-powdered using another media		+ Vapor Smoothed by AMT	
Surface roughness (Ra µm)				
	Horizontal surface	Vertical surface	Horizontal surface	Vertical surface
Ceramic medium	4.7	4.5	1.5	1.1
Corundum medium	4.4	3.5	1.8	1.5
Stainless Steel medium	5.6	5.4	1.9	1.8

SLS

	De-powdered using another media		+ Vapor Smoothed by AMT	
Surface roughness (Ra µm)				
	Horizontal surface	Vertical surface	Horizontal surface	Vertical surface
Ceramic medium	5.0	4.8	1.8	1.3
Corundum medium	2.8	4.2	2.0	2.9
Stainless Steel medium	5.4	3.7	2.6	2.4

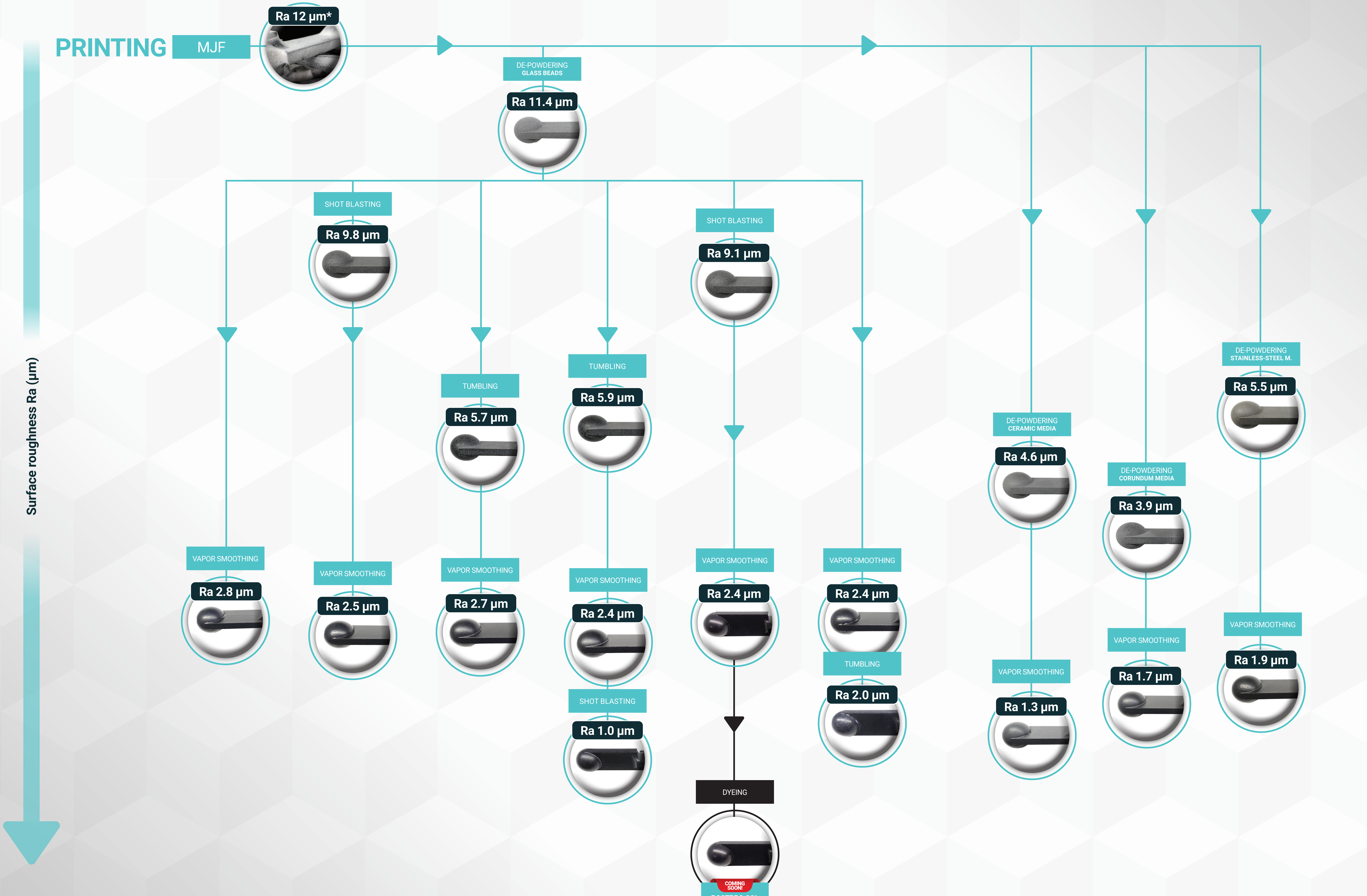
CONCLUSIONS

- Parts printed using the MJF technology tend to have rougher upwards facing surface when compared to sideways or downwards facing surfaces. Conversely, SLS parts tend to have rougher sideways facing surfaces. This characteristic could be contributed to the different methods in which the parts cool during processing.

- The best results, in terms of surface roughness, can be seen on parts which are treated both before and after Vapor Smoothing. In this case the best results were achieved when the parts were tumbled, vapor smoothed and then shot blasted.

- In terms of De-Powdering, a ceramic blasting medium appears to work best for MJF parts, whilst a corundum media worked best for SLS parts. In both cases there was a significant improvement when comparing the surface roughness of parts de-powdered using glass beads, in which the surface roughness improvement was insignificant.

- The improvement of tumbling or shot blasting a part before Vapor Smoothing compared to only de-powdered using glass beads, can be seen but the difference is minimal.



*Surface roughness values can vary depending on many factors. The ones mentioned on this document are average values result of own measurements.

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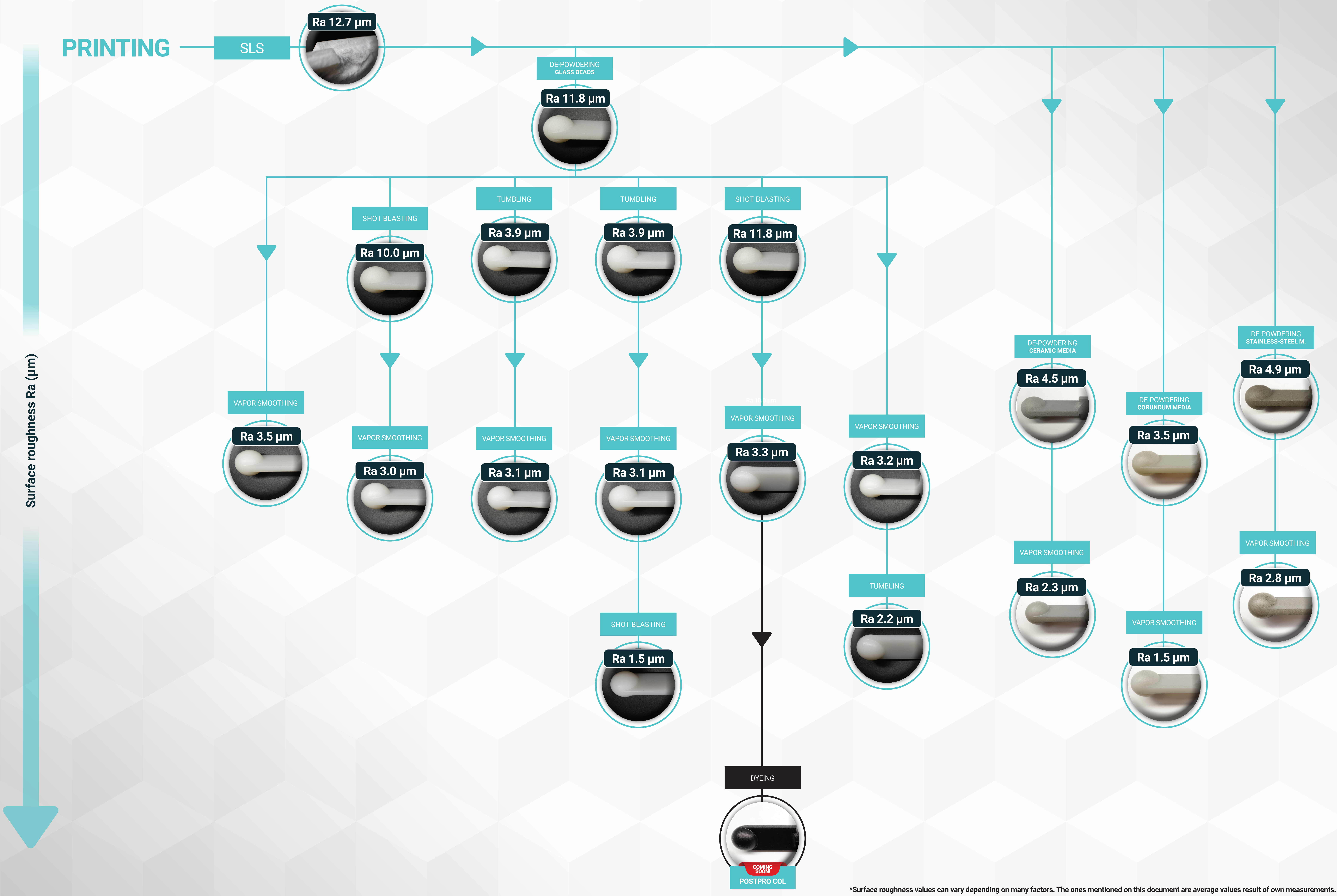

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