White paper

Electroplating and metal coating for MJF

Electroplating and metal coating are techniques used to add a layer of metal to the surface of a printed part. This is done to improve physical properties (conductivity, EMI/RFI shielding, mechanical strengthening, and heat conductivity), or to improve the look and feel of the part for cosmetic applications.

Executive summary

- MJF printed parts can be metalized in the same way as plastic injection parts can. The first step to metalize a plastic part is to make the surface conductive. In this newsletter, you will find three methods of accomplishing this:

Process	Short description	Advantages	Disadvantages
Electroless plating	Add small particles of palladium inside micro cracks in the surface.	Most common procedure in industry.	Geometry dependent, complex process.
Jet Metal Technology	Add a thin layer of metal with special red-ox painting solution.	Simple and scalable, selective metallization.	Geometry dependent, early stages of technological development.
Gas activation technology	Make the surface conductive with ionized gas.	Fast, selective metallization.	Small area non-electroplated due to the electrode connection

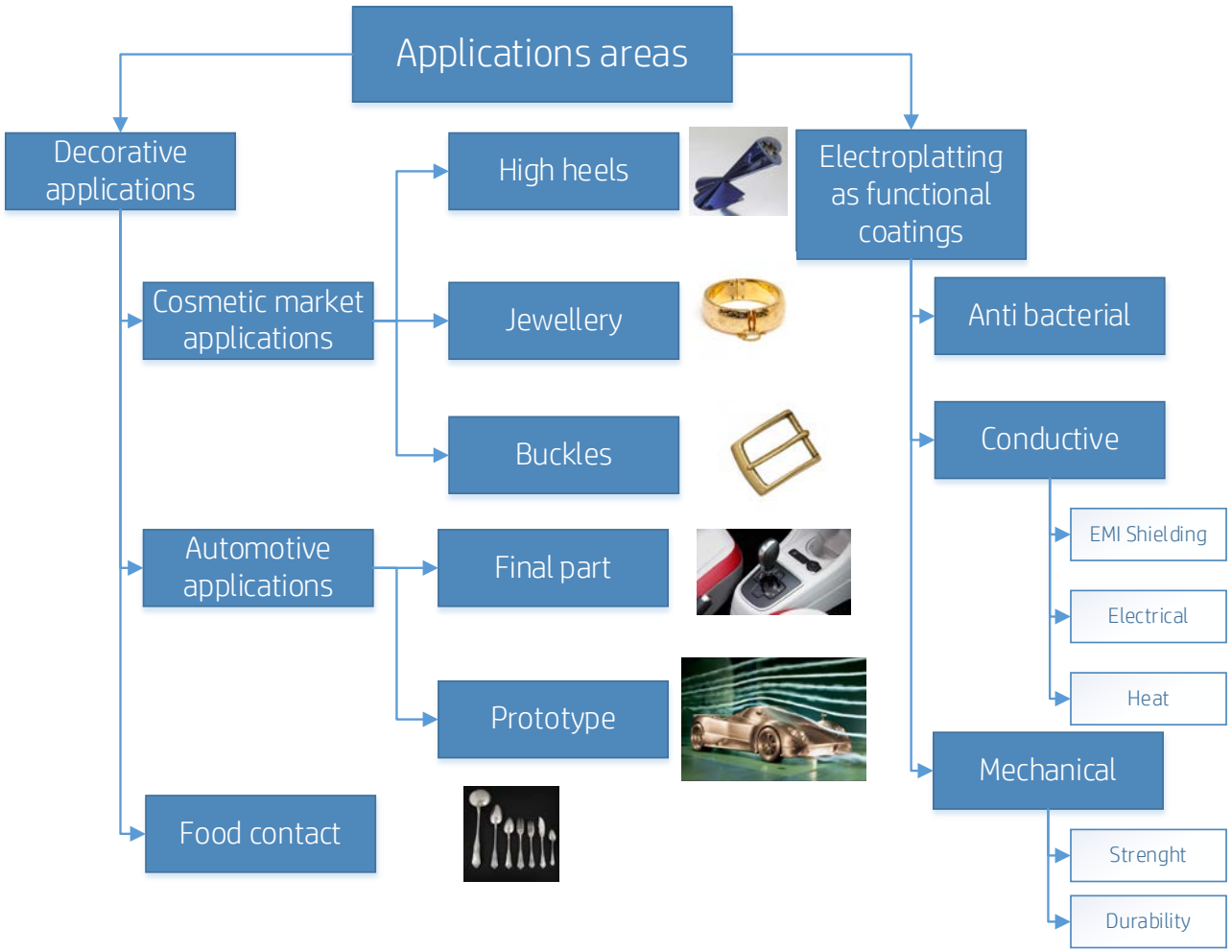
- As printed parts have higher roughness (Ra around 11 um) than injection parts, which will be reflected on the final surface, some preprocesses are recommended to minimize the roughness before metalizing them:

Number	Process	Ra achieved (um)	Comments
1	Placing the part upside down	8	Bottom surfaces are always smoother.
2	Tumbling	0.7	Geometry dependent, scalable.
3	Tumbling + primer (spray)	0.2	Geometry dependent, low porosity achievement.

- Different applications will require different preprocess and metallization process; in the following table, some examples are explained:

Application	Attribute	Preprocess recommendation	Metallization with
Cosmetic market applications	High quality surface finish (mirror)	3	Thick layer of electroplating (some small holes can be seen using Jet Metal)
Automotive applications	Dependent on final part or prototype	Final part: 3 Prototype: 2	Electroplating or Jet Metal
Food contact	Under investigation	2 or 3 (depending the surface quality needed)	Electroplating or Jet metal
Functional coating	Mechanical, antibacterial, conductivity…	1	Electroplating or Jet Metal

Applications for MJF printed parts



How does electroplating work?

Electroplating, or platting, is a process to add a thin layer of metal to a metallic object. At a basic level, it consists of dissolving one metal in a solution and subsequently attaching it to another metallic surface using an electric current. The target surface must be able to conduct electricity:

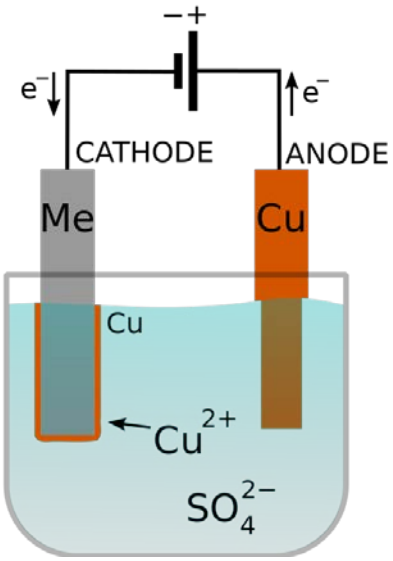


Figure 1: Electroplating or tank plating process

The following link provides a basic explanation on how to electroplate metal parts:
https://www.youtube.com/watch?v=ctL60c0STUU

To electroplate nonconductive parts, such as MJF printed parts, some preprocessing is required to make the surface conductive. Three methods are commonly used today:

Electroless platting

This is the most common procedure practiced by the current industry. It is a multi-step process:

1. **Mechanical etching**: A sand blaster is used to enhance surface-adhesive capabilities. For raw parts, we have observed that only mechanical etching is required, but with electroplated-tumbled parts, chemical etching must be used.

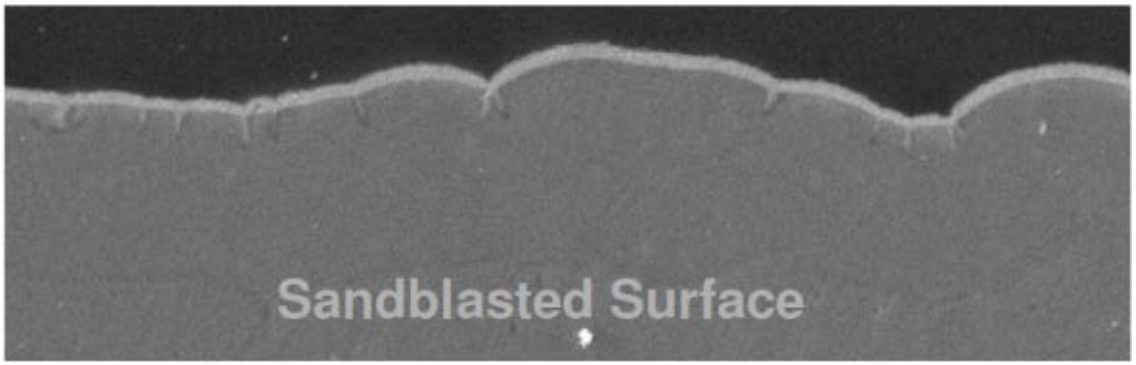


Figure 2: Part surface after being sandblasted

2. Chemical etching: To reinforce surface-adhesive capabilities, a chemical attack on the surface is performed with a chromic acid-based solution. Any excess chromic acid that is produced must then be neutralized.

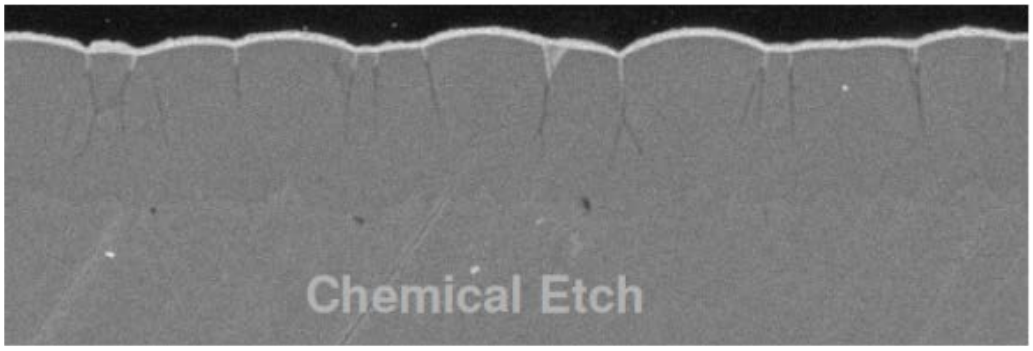


Figure 3: Part surface after being sandblasted + chemical etched

3. Palladium adhesion: A solution consisting of palladium (can be platinum and gold) and tin salts is then applied to the material.
4. Electroless plating: An electroless bath to deposit a thin metal coating. In most applications, nickel is the metal of choice, although copper plating on plastic is performed in some instances. Nickel is generally adequate for making the surface of the plastic conductive. However, copper is sometimes chosen for automotive parts because it is less resistant to blistering.

Jet Metal Technology

Jet Metal has developed a technology to add a thin layer of silver (15 um) to the surface which makes its surface conductive, and prepares it for electroplated. This consists spraying of 2 water-based solutions (oxidant and reducer) with standard painting equipment:

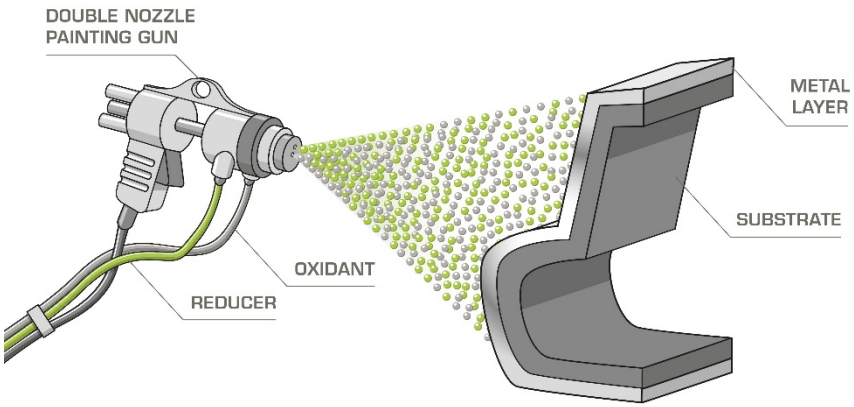


Figure 4: Jet Metal Process

Figure 5: Part electroplated with copper after Jet Metal process

Jet Metal technology also can be used selectively to add metal to only one zone, or a pattern on the part's surface:

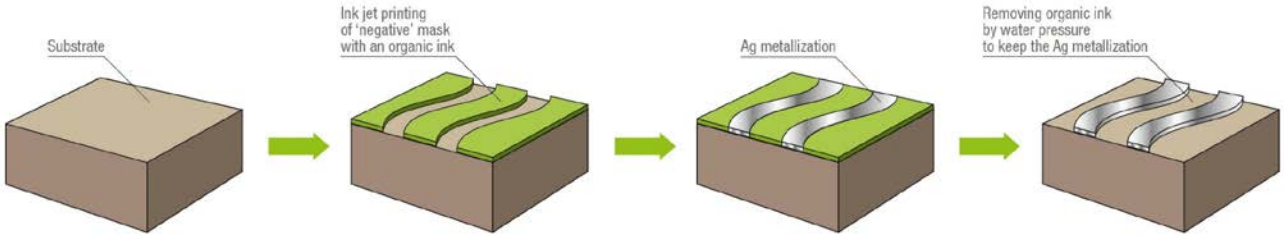


Figure 6: Schema for Jet Metal selective plating

Surface Activation Technology

SAT Plating has developed a new technology to make the surface conductive by applying a gas. This technology does not require mechanical or chemical etching and, therefore, the initial surface is not modified.

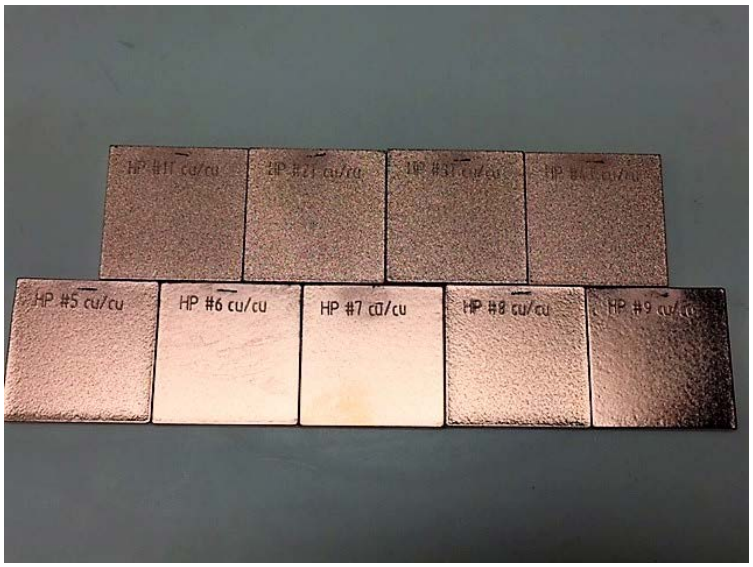


Figure 7: Preliminary results for plating with SAT Plating gas activation technology in MJF parts

Part Number	Measured Roughness before Activation Process
HP 1	9.45
HP 2	10.23
HP 3	9.24

HP 4	9.07
HP 5	1.33
HP 6	1.78
HP 7	1.58
HP 8	1.41
HP 9	1.83

Further studies need to be done to determine if the process of tumbler, painting, gas activation, and electroplating is feasible for MJF parts.

Similarly to Jet Metal technology, surface activation by gas can be used on parts and surfaces selectively.

Surface finish option for electroplating

RAW PART + ELECTROPLATING

Raw parts can be electroplated giving them desired physical properties, but due to the initial roughness of the part, they may not achieve the look and feel required for most of the cosmetical applications (for example if they need a mirror electroplated surface):

Figure 8: Raw part electroplated

TUMBLER + ELECTROPLATING

The tumbler process can be used to reduce the surface roughness of a given part (for a more detailed explanation see *Annex 1*). The process consists of doing a tumbler and then electroplating the part after. In this case, the surface will be more similar to a mirror, but due to porosity small holes can be seen. While this may be enough for some applications, for the cosmetic-applications market, these small holes have to be removed:

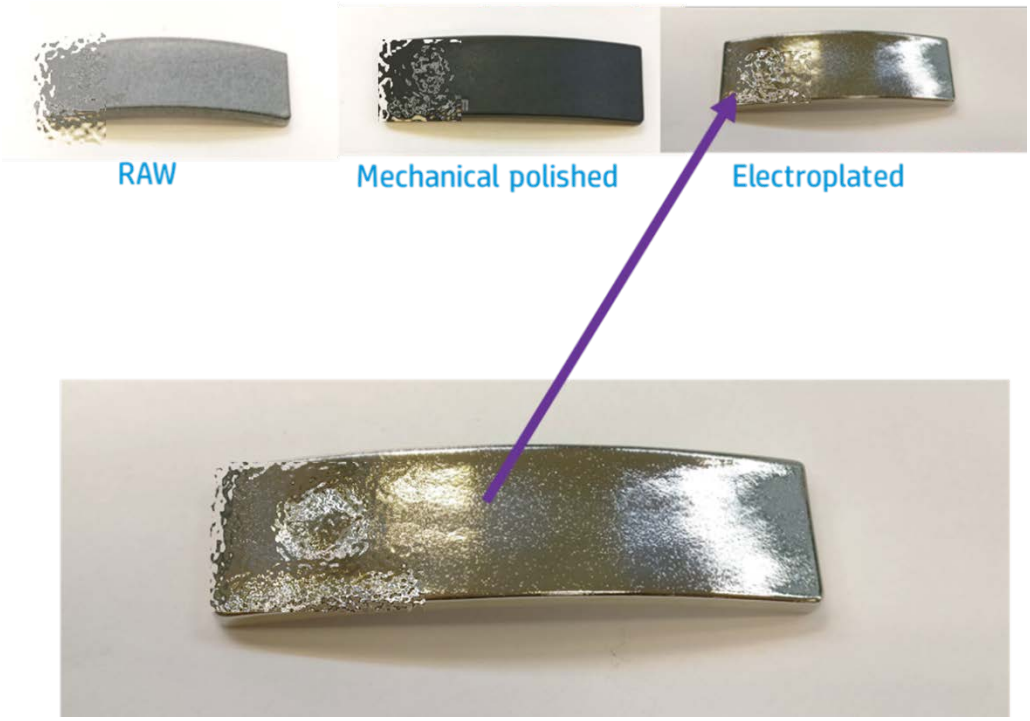


Figure 9: Tumbler + electroplating process schema

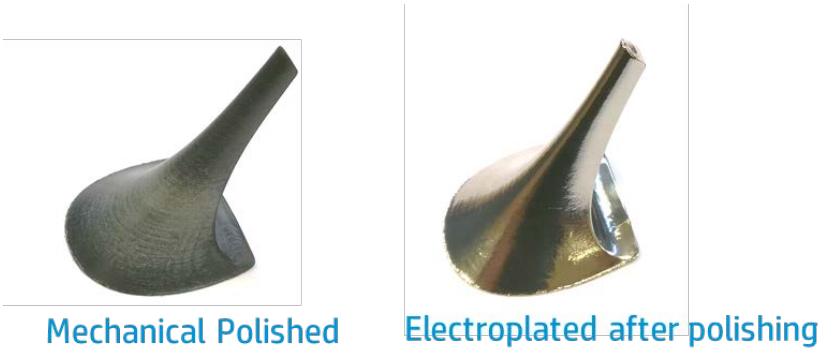


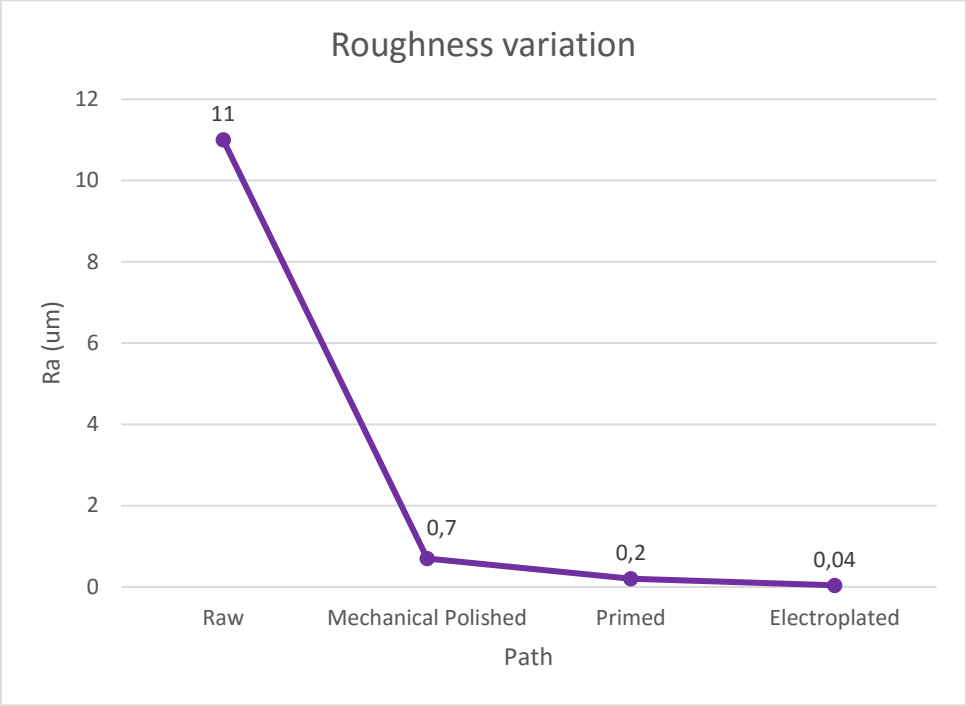
Figure 10: High heel electroplated after mechanical polishing

TUMBLER + PRIMER + ELECTROPLATING

In order to remove the small holes caused by porosity, a spray paint is applied after mechanical polishing and before the electroplating process:

Figure 11: Tumbler + priming + electroplating process photos

This process will allow the customer to have mirror-surface electroplated Multi Jet Fusion parts. In the following graph the variation of Ra (inverse proportional of surface quality) for every process can be observed:



Surface finish options for MJF parts with Jet Metal (metal coating)

Jet Metal has developed a process to fulfill cosmetic market applications requirements. This consists of adding a base coat before the Jet Metallization, and after this process, adding a top coat (usually a colored varnish).

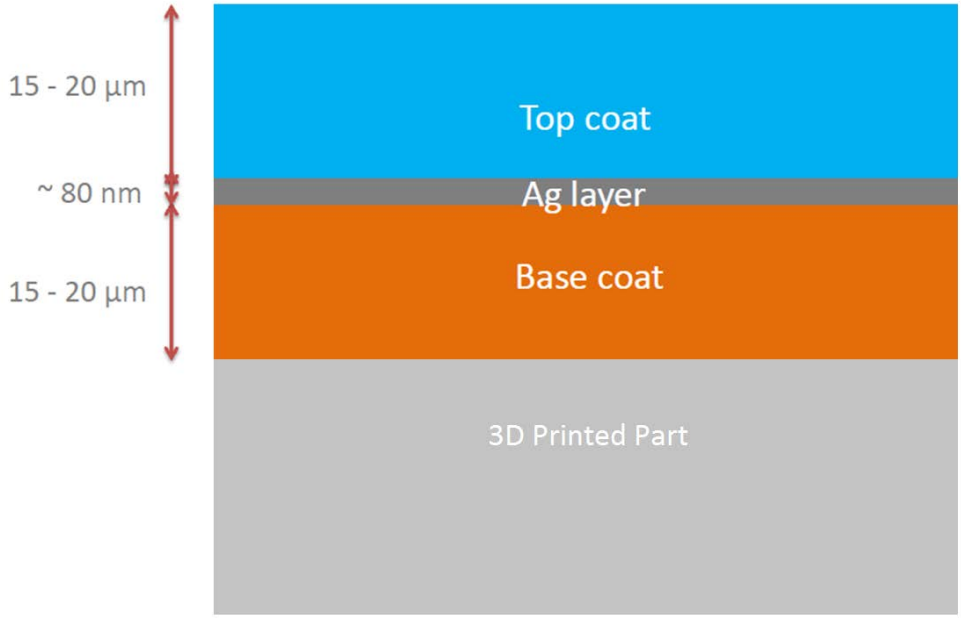


Figure 12: Jet Metal decorative process schema

RAW PART + JET METAL

If we use the Jet Metal process on a raw part, these are the results:

Figure 13: Raw part with decorative Jet Metal process

We can see, the results are very similar to electroplated a raw part (Figure 8).

TUMBLER + JET METAL

Using tumbler before the Jet Metal decorative process reduces roughness, but many small holes may still be seen:

TUMBLER + PRIMER + JET METAL

As with electroplating, tumbling plus painting is an effective solution to improve surface quality. But as the metal layer thickness is smaller than electroplating, small holes can still be observed in the surface (albeit far less than tumbler and electroplating):

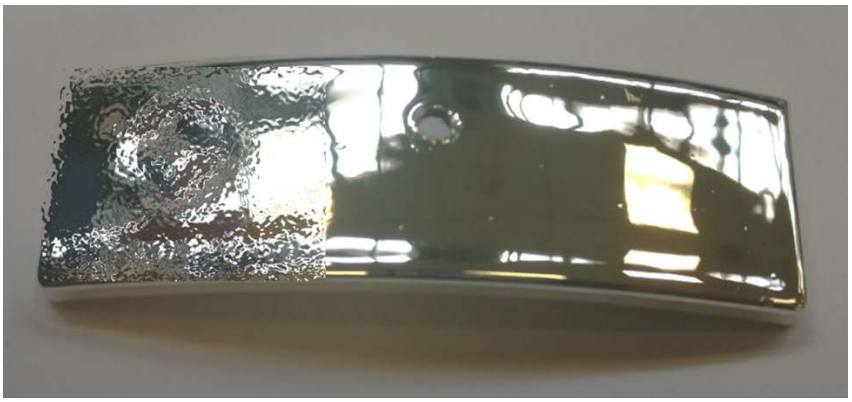


Figure 14: Tumbler +painted + Jet Metal

PRIMER + MANUAL POLISHING + JET METAL

Priming and after manual polishing is a very effective solution for certain costumers that do not require scalability (prototype, short runs, etc.) to have acceptable results for cosmetic applications. The roughness we achieve with this method is an Ra of around 0.13 um.

Figure 15: PRIMER + MANUAL POLISHING + JET METAL

Jet Metal summary

Figure 16, provides an analysis of achieved roughness (measured in Ra) in each step of the processes. (1) Raw and Jet Metal, (2) raw, tumbler, and Jet Metal, and (3) raw, tumbler, primer, and Jet Metal:

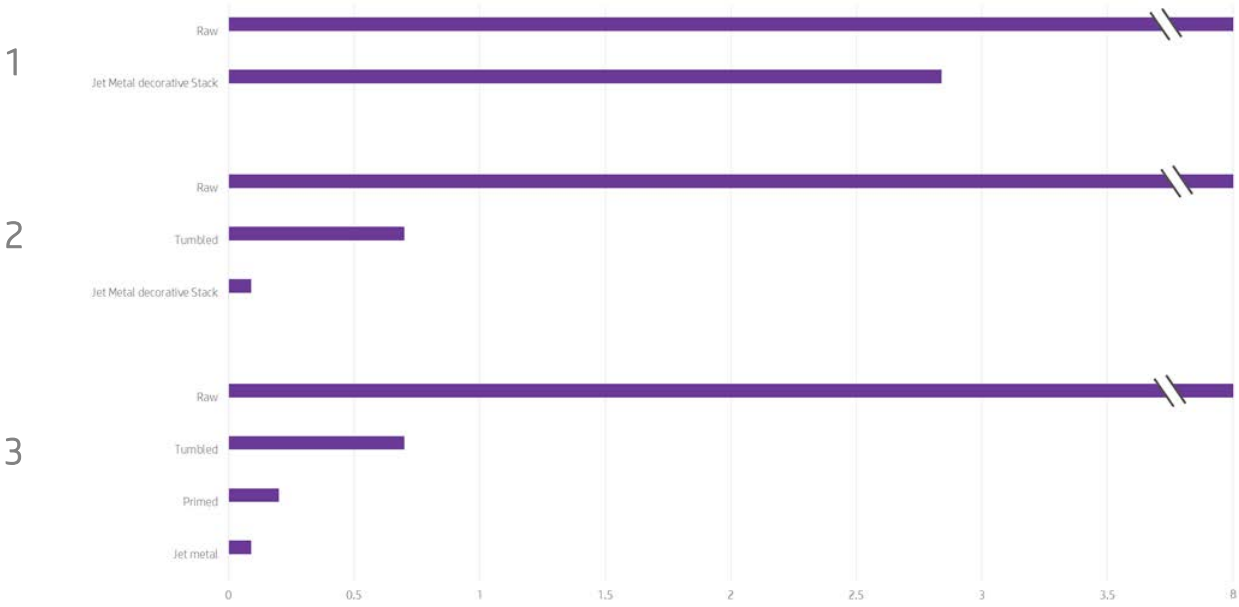


Figure 16: Ra measured in um for every step of the processes 1,2,3

It can be observed that the final roughness of process (2) and (3) and the method explained in the section 4 (primer, manual polishing, and Jet Metal) are the same. This leads to the conclusion that small holes are not due to roughness, but perhaps due to porosity instead (further investigation and research is required).

Annex

Tumbler process for surface roughness reduction

When the raw-part smoothness is not sufficient for the application, tumbling is an option to reduce roughness of the parts. However, this process also polishes and possibly erodes smaller and finer details of the part.

Figure 17: Rösler rotary tumbler

Choosing the right abrasive and tumbling time for the part is the key to reduce roughness without erasing small details.

Figure 18: Different abrasive types

Usually, the abrasive media has two main properties:

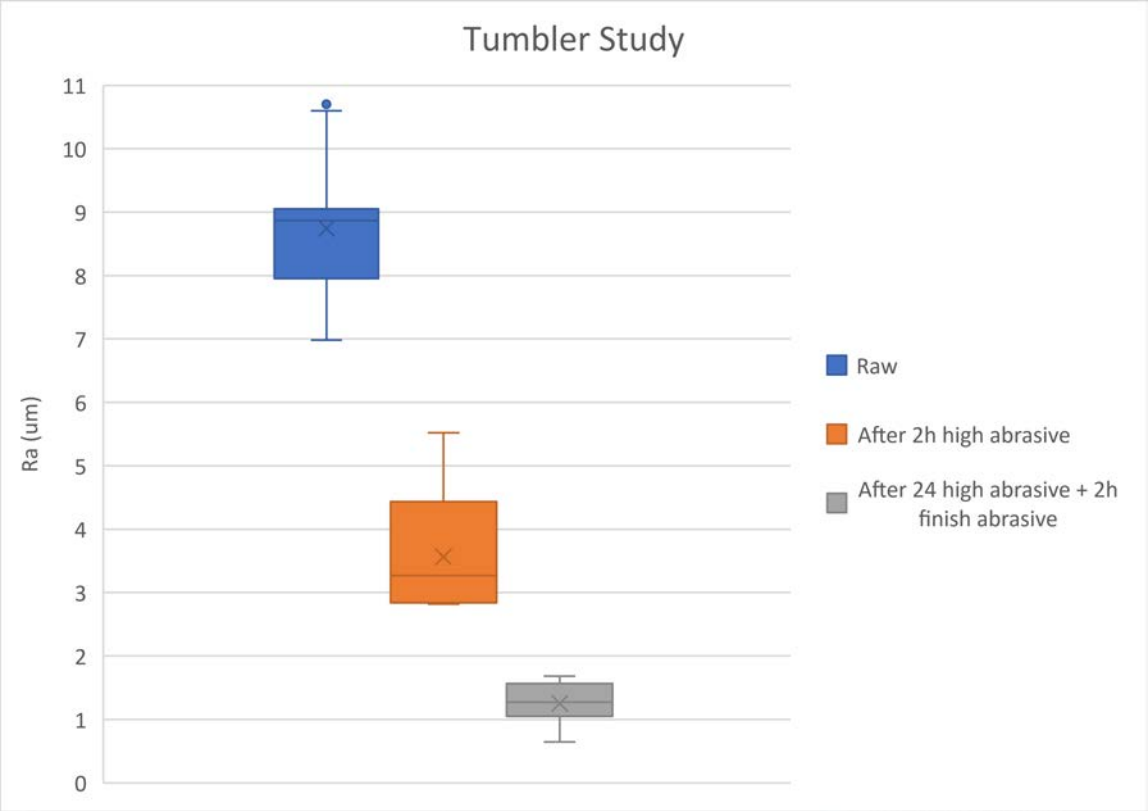
- **Power of abrasion:** More power of abrasion implies less tumbling time is required to reduce to a certain roughness.
- **Surface finish:** The quality of the surface after the tumble process.

The relationship between power of abrasion and surface finish is usually a trade-off. As high-aggressive abrasives have a bad surface finish, using one on a part that initial has a Ra of 11um will easily reduce it to 4

or 3 um. However, going farther than that will be difficult, as this kind of abrasive is likely to have a negative impact on finer details.

On the other hand, if we use a high-surface finish abrasive, it will take a large amount of time to reduce this roughness but it can achieve a lower Ra.

Using two abrasives is a viable strategy. First, to rapidly reduce roughness with an aggressive media, and after that, use a finer media to achieving lower values of roughness:



Partial results for tumbling process not official recommendations

Jet metal conductivity vs layer thickness