Plasma Polishing Technology
Traditional polishing process

- **Mechanical polishing**
  - Polish the metal surface by mechanical tools

- **Chemical polishing**
  - Polish the metal surface by chemical reaction

- **Electrochemical polishing**
  - Polish the metal surface by anodic dissolving
Limitations of traditional polishing process

- **Mechanical polishing**
  - Simple objects
  - Labor intensive/low efficiency
  - Dust explosion

- **Chemical polishing**
  - Poor uniformity of the gloss
  - Fire hazard
  - Expensive post-treatment of chemical solutions

- **Electrochemical polishing**
  - Corrosion of the polishing machines
  - Expensive post-treatment of polishing solutions
  - Poor dimensional tolerance
What is plasma
Design of multi-stage plasma polishing process

❖ **Operation process**

1\(^{st}\)
- Pre-treatment of the metallic object

2\(^{nd}\)
- Immerse the metallic object into the polishing solution

3\(^{rd}\)
- Gas film formed on the surface of the metallic object under high voltage
- Plasma discharged on the surface of the metallic object
Design of multi-stage plasma polishing process

- **Plasma polishing machine**
  - **Rectifier**
    - Provide high voltage
  - **Adjustable cathode**
    - Distance-adjustable octagonal cathode
  - **Anode with workpiece fixer**
    - Fix the metallic object on the anode
  - **Polishing tank**
    - Excellent chemical and thermal stability
  - **Washing tank**
    - Post-treatment of metallic object
Parameters of the plasma polishing process

Parameters

- Applied voltage: 300~600V
- Temperature of the polishing solution: 50-80 °C
- Polishing time: 1-6 min
- Material of the metallic object: metal or metal alloy
- pH of the polishing solution: 5-7
- Distance between electrodes: 1-10 cm
- Area ratio of metallic object and cathode: 1:1 to 1:50
Advantages of plasma polishing process

- Automatic polishing process
- Uniform roughness and gloss
- High dimensional tolerance
- Dust explosion
- No toxic solution and waste
Material Characterization Method

- **Glossmeter**
  - Gloss is an optical property which indicates how well a surface reflects light in a specular (mirror-like, >600 GU) direction.

- **Morphology**
  - The morphology of a surface is characterized by an optical microscope with a digital camera.
Material Characterization Method

- **Roughness meter**
  - Roughness is the average of vertical deviations from nominal surface over a specified length surface.

![Stylus Profilometer](image1)
![Optical Profilometer](image2)
Plasma polishing of stainless steel (SS)

- Watch bracelet
- Watch case
- Watch clasp
- Glasses
Plasma polishing results of watch bracelet (SS)

Unpolished

Rough polishing

Fine polishing

Unpolished

Rough polishing

Fine polishing

300 V
60°C
3 min

300 V
60°C
3 min
Plasma polishing results of watch case (SS)

**Roughness (Ra)**

- **Unpolished**
- **Rough polishing**
- **Fine polishing**

**Gloss (GU)**

- **Unpolished**
- **Rough polishing**
- **Fine polishing**

**Details:**
- **Unpolished:**
  - Voltage: 300 V
  - Temperature: 60°C
  - Time: 3 min

- **Rough polishing:**
  - Voltage: 400 V
  - Temperature: 80°C
  - Time: 3 min

- **Fine polishing**

![Images of unpolished, rough polished, and fine polished watch cases](image-url)
Plasma polishing results of watch clasp (SS)

- Unpolished
- Rough polishing
- Fine polishing

Roughness (Ra)

Gloss (GU)

- Unpolished
- Rough polishing
- Fine polishing

300 V
60°C
3 min

300 V
80°C
3 min
Plasma polishing results of glasses (SS)

Polishing condition: 300 V 80°C 2 min

![Graph showing Roughness Ra (μm) comparison between Unpolished and Fine polishing conditions. The bar graph indicates a significant reduction in roughness after fine polishing.]
Plasma polishing of Copper sample

Polishing condition: 300 V 80°C 3 min

<table>
<thead>
<tr>
<th>Roughness (mm)</th>
<th>Unpolished</th>
<th>Polished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roughness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unpolished</td>
<td>Polished</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Gloss (GU)</th>
<th>Unpolished</th>
<th>Polished</th>
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<tbody>
<tr>
<td>Gloss</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unpolished</td>
<td>Polished</td>
</tr>
</tbody>
</table>

Unpolished | Polished

Unpolished | Polished
Plasma polishing of Titanium (Ti)

Polishing condition: 550 V 85°C 1 min
## Summary

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<thead>
<tr>
<th></th>
<th>Traditional polishing process</th>
<th>Plasma polishing process</th>
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<tbody>
<tr>
<td>Polishing time</td>
<td>&gt; 10 minutes</td>
<td>1-6 minutes</td>
</tr>
<tr>
<td>Simple process</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Labor-intensive</td>
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<td>No</td>
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<tr>
<td>Removal of material</td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td>Post-treatment of polishing solution</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Environmental-friendly</td>
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Q&A