SMT Solder Paste Printing For Fine-Pitch

Satoru Akita
General Manager
Senju Metal Industry Co., Ltd.
Solder Technical Center

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In addition to solder paste, it is essential to control the components, equipment, and process.
Considerations for Fine Pitch Assembly

To enable consistent Fine Pitch assembly:

- **Printing**
  - Aperture design
  - Stencil side-walls
  - Ensure print release defects, misalignments, and other abnormalities are detected.

- **Mounting**
  - Mount load
  - Mount accuracy
  - Ensure missing or misaligned components are detected.

- **Reflow**
  - Preheat setup
  - Peak temp & time
  - Ramp-up speed

Use paste with good print release and stability

Use paste with high tack force

Use paste with high heat-resistant
Contents

✓ Solder Paste Selection
  • Solder Powder Size
  • FLUX
✓ Stencil Selection
✓ Suitable Printing Parameters
✓ Suitable Reflow Profile
Smaller aperture opening area is more difficult to deposit paste as compared to larger devices.

- It is critical to fill the apertures effectively.
Printability Test:

Effects of different stencil thickness vs. powder size

- **Stencil Thickness: 40um**
- **Stencil Thickness: 60um**

When aperture size is small, Type 6 paste can achieve higher print volume and stability.
Contents

✓ Solder Paste Selection
  • Solder Powder Size
  • FLUX

✓ Stencil Selection

✓ Suitable Printing Parameters

✓ Suitable Reflow Profile
## Oxide Film

### Oxide Film Thickness by Powder Size (Theoretical):

<table>
<thead>
<tr>
<th>Powder Size</th>
<th>Surface Area Ratio per One Particle</th>
<th>Powder Number Ratio per Unit Volume</th>
<th>Surface Area Ratio per Unit Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 4: 20 ~ 38um</td>
<td>9</td>
<td>8</td>
<td>72</td>
</tr>
<tr>
<td>Type 5: 15 ~ 25um</td>
<td>4</td>
<td>27</td>
<td>108</td>
</tr>
<tr>
<td>Type 6: 5 ~ 15um</td>
<td>1</td>
<td>216</td>
<td>216</td>
</tr>
</tbody>
</table>

*Calculation based on average size of Type 4 (30um), Type 5 (20um), Type 6 (10um)*

- **Surface area of Type 6 is three times more than Type 4 = oxide film thickness is three times. Oxidation risk is greater with finer powder size**
Effects of Solder Oxidation

Oxidation during Reflow:

When powder oxidation increases, flux’s ability to remove oxide layers decreases and causes solder balls and non-wets.

Difficult to achieve with conventional flux
When components are mounted, reflowability worsens as flux also needs to remove the oxidation on the component side.

By optimizing flux, it enables successful soldering!
Contents

✓ Solder Paste Selection
  • Solder Powder Size
  • FLUX

✓ Stencil Selection

✓ Suitable Printing Parameters

✓ Suitable Reflow Profile
Different Sidewall Conditions of the Stencil

- Supplier A: Burr
- Supplier B
- Insufficient Printing
- Additive Process
- Standard Laser Process
- High Performance Laser Process

It is critical to use stencils with smooth sidewalls.
For small apertures, thicker stencil will produce poor print definition and transfer volume becomes inconsistent.

→ It is important to select the most suitable stencil thickness.
Aspect Ratio:

\[
\text{Aspect Ratio} = \frac{\text{Area of aperture wall}}{\text{Area beneath the aperture opening}} = \frac{4t}{d}
\]

- t: stencil thickness
- d: aperture diameter

When aspect ratio is larger, printing becomes more difficult.

In general, aspect ratio of 2.0 or lower is recommended.

<table>
<thead>
<tr>
<th>Aperture Opening Size</th>
<th>Stencil thickness/ um</th>
<th>Aspect ratio/ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>200um</td>
<td>80</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Printability of Bumping

- **150umPitch**
  - Stencil opening: **110um**
  - (Aspect ratio: 1.5%)

- **120umPitch**
  - Stencil opening: **90um**
  - (Aspect ratio: 1.8%)

- **120umPitch**
  - Stencil opening: **80um**
  - (Aspect ratio: 2.0%)

- Stencil: Process Lab Nano Coating
- Stencil Thickness: 40 um
- Solder Paste: Senju BPS Type 7 Series
- Printer: Dek Proflow
Dry Film Printing Method

Process:


Substrate size

<table>
<thead>
<tr>
<th>Item</th>
<th>Pitch(um)</th>
<th>SRO(um)</th>
<th>SRT(um)</th>
<th>DFO(um)</th>
<th>DFT(um)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>110</td>
<td>55</td>
<td>20</td>
<td>65</td>
<td>30</td>
</tr>
</tbody>
</table>

- Dry Film Aperture Opening Size: 200×240mm
- Dry Film Thickness: 0.3mm
- Solder Paste : Senju M705-DFS-Series
Contents

✓ Solder Paste Selection
  • Solder Powder Size
  • FLUX

✓ Stencil Selection

✓ Suitable Printing Parameters

✓ Suitable Reflow Profile
Considerations Inside the Printer

Make sure there is no scraping leftover in the printing area

- Excess volume for large opening
- Poor release for small opening

- To prevent residues -
  - Adjust print pressure
  - Control Squeegee
  - Backup properly
Print Parameter Setup

Printing Conditions:
To ensure high printing quality of very small apertures, it is necessary to optimize printing parameters.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Recommended Conditions (Ex.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printer Type</td>
<td>Open Squeegee</td>
</tr>
<tr>
<td>Squeegee Type</td>
<td>Metal</td>
</tr>
<tr>
<td>Squeegee Angle</td>
<td>60°</td>
</tr>
<tr>
<td>Print Speed</td>
<td>30-50mm/s</td>
</tr>
<tr>
<td>Print Pressure</td>
<td>0.20-0.30N/mm</td>
</tr>
<tr>
<td>Separation Speed</td>
<td>1.0-5.0mm/s</td>
</tr>
<tr>
<td>Print Environment</td>
<td>22-28°C, 40-60%RH</td>
</tr>
</tbody>
</table>

- It is especially important to control print speed and separation speed
Printing Speed

Printing Speed (20, 30, 40, 50, 100, 200 mm/s):

Print speed affects deposit time and pressure which can impact volume transferability.

- Paste rolling
- Fill the stencil aperture
- Complete

- Vol distribution
- Deviation

Too fast or too slow speed will cause greater variations in transfer volume
Separation Speed

Separation Speed (0.1, 0.5, 1.0, 2.5, 5.0, 10.0mm/sec):

Separation speed affects the adhesion to the aperture walls which can significantly impact paste release & print definition.

Key is to minimize solder buildup on walls.

- Slow separation speed can cause poor print definition and lower transfer volume, leading to larger variations.
Contents

✓ Solder Paste Selection
  • Solder Powder Size
  • FLUX
✓ Stencil Selection
✓ Suitable Printing Parameters
✓ Suitable Reflow Profile
Critical Parameters of Reflow Profile

Reflow Profile Guideline:

① Ramp-to-soak
- Recommended rate (avg): 2~4°C/s

② Preheat/Soak
- Recommended temp: 140~170°C
- Recommended time: Around 70sec

③ Ramp-to-peak
- Recommended rate (avg): 2~3°C/s

④ Reflow
- Recommended peak temp: 230~245°C
- Time above liquidus (220°C): Over 30sec

It is important to control preheat zone (where oxidation is likely to occur) and ramp-to-peak rate
Mixed Component Mounting

When more solder volume is needed for larger components:

When solder joint strength becomes a concern for larger devices,

- Stencil design change
- Chip solder

are best possibilities

From solder paste approach...

- Jet Dispense Process -
  - Process to supplement solder volume of printing paste
  - Non-contact
  - Shorter tact time as compared to air dispense
Potential Increase in Strength by Jet Dispensing

Shear Strength by Print Thickness:

Effects of strength by adding solder (1608 chip capacitor)

- Adding solder volume by jet dispensing can potentially increase strength
- Due to new process, further verification testing is needed

<table>
<thead>
<tr>
<th>Stencil Thickness</th>
<th>Avg Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12t</td>
<td>40.08</td>
</tr>
<tr>
<td>0.10t</td>
<td>33.13</td>
</tr>
<tr>
<td>0.08t</td>
<td>26.54</td>
</tr>
<tr>
<td>0.08t + JET</td>
<td>37.13</td>
</tr>
</tbody>
</table>

*Solder Paste : Senju NXD900ZH series
To achieve successful Fine Pitch assembly:

- **Solder Paste Selection**
  - Solder powder: Select fine powder (< Type 6: 5 ~ 15um)
  - Flux: Select high oxidation-resistance & high heat-resistance chemistries

- **Stencil Selection**
  Select stencil with very smooth aperture walls
  Select aperture design with 2.0 or lower aspect ratio

- **Printing Parameter Setting**
  Set suitable parameters (especially separation speed)

- **PCB Quality (Plating/Resist)**
  Ensure there is no contamination of the plating and resist is aligned

- **Reflow Profile**
  Set suitable preheat temp/time & ramp-up speed

- For Fine Pitch assembly, it is essential to increase overall accuracy