Printing Practices for 01005 Components

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Outline/Agenda

- Introduction
- 01005 Components-Size, Shape and usage
- Stencil Design
- Transfer Efficiencies
- Q & A
Introduction

01005 components are a challenge due to their size
Introduction

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Introduction

**Murata Manufacturing Company**

Why Use 01005 Components?

- Small size allows for use in high density circuit boards.
- Cell phones, Bluetooth applications, wireless LAN and wearable technology
Why Use 01005 Components?
Why Use 01005 Components?
Printing Challenges

Proper paste printing requires:

- Optimized Stencil design
- Best Stencil Material
- Best Coating Technology
- Proper Solderpaste Type
# Stencil Design

## Table 3-2 General Aperture Design Guideline Examples for Selective Surface-Mount Devices (Tin Lead Solder Paste)

<table>
<thead>
<tr>
<th>Part Type</th>
<th>Pitch</th>
<th>Land Footprint Width</th>
<th>Land Footprint Length</th>
<th>Aperture Width</th>
<th>Aperture Length</th>
<th>Stencil Thickness Range</th>
<th>Aspect Ratio Range</th>
<th>Area Ratio Range</th>
<th>Solder Paste Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLCC</td>
<td>1.25 mm [49.2 mil]</td>
<td>0.65 mm [25.6 mil]</td>
<td>2.00 mm</td>
<td>0.60 mm</td>
<td>1.95 mm</td>
<td>0.15 - 0.25 mm [5.91 - 9.84 mil]</td>
<td>2.4 - 4.0</td>
<td>0.92 - 1.53</td>
<td>Type 3</td>
</tr>
<tr>
<td>QFP</td>
<td>0.65 mm [25.6 mil]</td>
<td>0.35 mm [13.8 mil]</td>
<td>1.50 mm</td>
<td>0.30 mm</td>
<td>1.45 mm</td>
<td>0.15 - 0.175 mm [5.91 - 6.89 mil]</td>
<td>1.7 - 2.0</td>
<td>0.71 - 0.83</td>
<td>Type 3</td>
</tr>
<tr>
<td>QFP</td>
<td>0.50 mm [19.7 mil]</td>
<td>0.30 mm [11.8 mil]</td>
<td>1.25 mm</td>
<td>0.25 mm</td>
<td>1.20 mm</td>
<td>0.125 - 0.15 mm [4.92 - 5.91 mil]</td>
<td>1.7 - 2.0</td>
<td>0.69 - 0.83</td>
<td>Type 3</td>
</tr>
<tr>
<td>QFP</td>
<td>0.40 mm [15.7 mil]</td>
<td>0.25 mm [9.84 mil]</td>
<td>1.25 mm</td>
<td>0.20 mm</td>
<td>1.20 mm</td>
<td>0.10 - 0.125 mm [3.94 - 4.92 mil]</td>
<td>1.6 - 2.0</td>
<td>0.69 - 0.86</td>
<td>Type 3</td>
</tr>
<tr>
<td>QFP</td>
<td>0.30 mm [11.8 mil]</td>
<td>0.20 mm [7.87 mil]</td>
<td>1.00 mm</td>
<td>0.15 mm</td>
<td>0.95 mm</td>
<td>0.075 - 0.125 mm [2.95 - 4.92 mil]</td>
<td>1.2 - 2.0</td>
<td>0.52 - 0.86</td>
<td>Type 3</td>
</tr>
<tr>
<td>0402</td>
<td>N/A</td>
<td>0.60 mm [19.7 mil]</td>
<td>0.65 mm</td>
<td>0.45 mm</td>
<td>0.60 mm</td>
<td>0.125 - 0.15 mm [4.92 - 5.91 mil]</td>
<td>N/A</td>
<td>0.86 - 1.03</td>
<td>Type 3</td>
</tr>
<tr>
<td>0201</td>
<td>N/A</td>
<td>0.4 mm [15.7 mil]</td>
<td>0.45 mm</td>
<td>0.23 mm</td>
<td>0.35 mm</td>
<td>0.075 - 0.125 mm [2.95 - 4.92 mil]</td>
<td>N/A</td>
<td>0.56 - 0.93</td>
<td>Type 3</td>
</tr>
<tr>
<td>01005</td>
<td>N/A</td>
<td>0.200 mm [7.87 mil]</td>
<td>0.300 mm [11.81 mil]</td>
<td>0.175 mm [6.89 mil]</td>
<td>0.250 mm [9.87 mil]</td>
<td>0.063 - 0.089 mm [2.5 - 3.5 mil]</td>
<td>N/A</td>
<td>0.58 - 0.81</td>
<td>Type 4</td>
</tr>
<tr>
<td>BGA</td>
<td>1.25 mm [49.2 mil]</td>
<td>CIR</td>
<td>0.55 mm [21.6 mil]</td>
<td>0.52 mm [20.45 mil]</td>
<td>0.15 - 0.20 mm [5.91 - 7.87 mil]</td>
<td>N/A</td>
<td>0.65 - 0.86</td>
<td>Type 3</td>
<td></td>
</tr>
<tr>
<td>Fine-pitch BGA</td>
<td>1.00 mm [39.4 mil]</td>
<td>CIR</td>
<td>0.45 mm [15.7 mil]</td>
<td>SQ</td>
<td>0.42 mm [13.8 mil]</td>
<td>0.115 - 0.135 mm [4.53 - 5.31 mil]</td>
<td>N/A</td>
<td>0.65 - 0.76</td>
<td>Type 3</td>
</tr>
<tr>
<td>Fine-pitch BGA</td>
<td>0.50 mm [19.7 mil]</td>
<td>CIR</td>
<td>0.25 mm [9.84 mil]</td>
<td>SQ</td>
<td>0.028 mm [11.0 mil]</td>
<td>0.075 - 0.125 mm [2.95 - 4.92 mil]</td>
<td>N/A</td>
<td>0.56 - 0.93</td>
<td>Type 3</td>
</tr>
<tr>
<td>Fine-pitch BGA</td>
<td>0.40 mm [15.7 mil]</td>
<td>CIR</td>
<td>0.20 mm [7.87 mil]</td>
<td>SQ</td>
<td>0.023 mm [9 mil]</td>
<td>0.075 - 0.100 mm [2.95 - 4 mil]</td>
<td>N/A</td>
<td>0.56 - 0.75</td>
<td>Type 4</td>
</tr>
</tbody>
</table>

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**Note 1:** It is assumed that the fine-pitch BGA lands are not solder mask defined.

**Note 2:** N/A implies that only the area ratio should be considered.
Stencil Design

01005 IPC Recommended Land Size

- .15 mm (6 mil) min.
- .300 mm (11.81 Mil)
- .200 mm (7.87 Mil)

Legend:
- Gray: Land Pad
- Blue: Component
- Pink: Stencil Aperture
Stencil Design

01005 IPC Recommended Aperture Size

- Land Pad: 0.250 mm (9.87 mil)
- Component: 0.175 mm (6.89 mil)
- Stencil Aperture: 0.200 mm (7.87 Mil)
- Minimum Aperture: 0.15 mm (6 mil)
Stencil Design

The IPC aperture design produces an Area Ratio of:

5 mil = .41    4 mil = .51    3 mil = .68
01005 Land Designs in Manufacturing Environments: Approx. 30% smaller than IPC

Land Pad should be available under components to allow paste to flow during placement and reflow.
Stencil Design

01005 Land Designs in Manufacturing Environments: Must Balance Volume and Placement Pressure
Stencil Design

01005 Land Designs in Manufacturing Environments: Reduced Volume/Less Pressure-Optimized Reflow
Stencil Design

01005 Land Designs in Manufacturing Environments

- Minimize overprint, float and skew by reducing Land Size
- Print 7.5 mil aperture, radius corners 2 mils to improve release

![Stencil Design Diagram]

- Land Pad
- Component
- Stencil Aperture
Stencil Design

01005 Land Designs in Manufacturing Environments

- 6 mil Rounded Square
- 7.6 Mil
- 8.4 Mil

Legend:
- Land Pad
- Component
- Stencil Aperture
Material Types:

Fine grain steel gives smoother side walls
Improves Paste Transfer Efficiency

Mill grade steel (500X)
25-30 µm

Fine grain steel (500X)
8-9 µm
Material Types:

Fine grain steel gives smoother side walls
Improves Paste Transfer Efficiency

Standard SS Microstructure
Grain Size: 15-30μm

Datum PhD Microstructure
Grain Size: 7-11μm
Material Types:
Fine Grain or Finer Grain?

Fine grain steel gives smoother side walls

Datum FG/Tension Foil is now down to the 2-3 micron Grain Size and is the best Performing material available.
Fine Grain Stencils

- Fine grain steel reduces the min. area ratio
- Minimum area ratios
  - Mill grade steel = 0.66 (industry standard)
  - Fine grain steel = 0.55 (with no coating)
Nano Coatings

- Polymer Nano Coatings can reduce min area ratios and maintain acceptable TE% 

- Minimum area ratios
  - Fine grain steel = 0.55
  - Fine grain steel + Nano Coating = 0.45
Transfer Efficiency Experiment
Equipment and Materials

- **Essemtec printer**
  - 20 mm/sec, 0.18 Kg/cm, 1.5 mm/sec

- **ASC International SPI**
  - AP212 with VM150 sensor

- **Solder paste**
  - No clean, lead free, SAC305

- **Stencils**
  - Datum PhD

- **Copper Clad Board**
# SAR Test Design

<table>
<thead>
<tr>
<th>Size (mils)</th>
<th>Shape</th>
<th>Pitch (mm)</th>
<th>Volume (mil³)</th>
<th>Area Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 mil stencil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RSQ</td>
<td>1</td>
<td>180</td>
<td>0.300</td>
</tr>
<tr>
<td>7</td>
<td>RSQ</td>
<td>1</td>
<td>245</td>
<td>0.350</td>
</tr>
<tr>
<td>7.5</td>
<td>RSQ</td>
<td>0.5</td>
<td>281</td>
<td>0.380</td>
</tr>
<tr>
<td>8</td>
<td>RSQ</td>
<td>1</td>
<td>320</td>
<td>0.400</td>
</tr>
<tr>
<td><strong>4 mil stencil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RSQ</td>
<td>1</td>
<td>144</td>
<td>0.380</td>
</tr>
<tr>
<td>7</td>
<td>RSQ</td>
<td>1</td>
<td>196</td>
<td>0.440</td>
</tr>
<tr>
<td>7.5</td>
<td>RSQ</td>
<td>0.5</td>
<td>225</td>
<td>0.470</td>
</tr>
<tr>
<td>8</td>
<td>RSQ</td>
<td>1</td>
<td>256</td>
<td>0.500</td>
</tr>
<tr>
<td><strong>3 mil stencil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RSQ</td>
<td>1</td>
<td>108</td>
<td>0.500</td>
</tr>
<tr>
<td>7</td>
<td>RSQ</td>
<td>1</td>
<td>147</td>
<td>0.580</td>
</tr>
<tr>
<td>7.5</td>
<td>RSQ</td>
<td>0.5</td>
<td>169</td>
<td>0.630</td>
</tr>
<tr>
<td>8</td>
<td>RSQ</td>
<td>1</td>
<td>192</td>
<td>0.670</td>
</tr>
</tbody>
</table>
1st Experiment

- Compare TE of 3 mil, 4 mil and 5 mil Foil, Uncoated
- Compare TE of Type 3 vs Type 4 paste
- Draw Conclusions
Solder Paste & TE

0.005” thick stencil, Uncoated
Solder Paste & TE

0.004” thick stencil, Uncoated
Solder Paste & TE

0.003” thick stencil, Uncoated
Stencil Thickness Summary

- Type 4 solder paste gives higher TE than Type 3
- 5 mil thick stencil does not work for 01005s
- 4 mil thick stencil and Type 4 paste acceptable
- 3 mil thick stencil is the best option
- 3 mil thick stencils works with Type 3 & 4 pastes
2nd Experiment

- Compare TE of 3 mil, 4 mil and 5 mil Foil, With Nanocoated Polymer
- Compare TE of Type 3 vs Type 4 paste
- Draw Conclusions
Solder Paste & TE

0.005” thick stencil, Nano Coat Polymer
Solder Paste & TE

Mean (Transfer Efficiency) vs. Location

0.004” thick stencil, Nano Coat Polymer
Solder Paste & TE

0.003” thick stencil, Nano Coat Polymer
Nano Coating Polymer Summary

- 5 mil Nano coated stencil still low TE
- 4 mil Nano coated stencil and Type 4 paste works well
- 3 mil Nano coated stencil gave exceptional TE
Summary: Uncoated Stencils

3 mil uncoated stencil & Type 4 paste near 70% TE
Summary: Nano Coated Polymer Stencils

3 and 4 mil Nano coated stencils gave > 70% TE
5 mil Stencil Summary

5 mil Stencils, Coated and Uncoated
4 mil Stencil Summary

4 mil Stencils, Coated and Uncoated
3 mil Stencil Summary

3 mil Stencils, Coated and Uncoated
Transfer Efficiency Summary

- Adequate TE% can be achieved
  - 4 mil Nano coated stencil with Type 4 paste
  - 3 mil uncoated stencil with Type 4 paste
  - 3 mil Nano coated stencil with Type 3 paste
- 5 mil stencil too thick – area ratios too low
Conclusion

- Recommended Stencil Design
  - 4 mil Stencil, Standard Phd material
  - 7.5 mil Square Aperture, 2 mil Radius Corners
  - Nano coated polymer coating
Notes For Further Study

- “Fine Grain/Tension” Foil needs to be examined to determine the effect of TE with and without Polymer Nanocoatings on different foil thicknesses.
- Type 5 Solderpaste needs to be examined to determine the effect on TE with different foil types and thicknesses.
Any Questions?

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