Root Cause Stencil Design for SMT Component Thermal Lands

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Outline/Agenda

- Introduction
  - Stencil design for thermal pads
- Experimental Methodology
  - Circuit board & stencil designs
  - Process & parameters
- Results & Discussion
  - D-Paks
  - Voiding QFNs & QFPs
  - Float - Skew - Bridging
- Conclusions
- Future Work

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Introduction

Stencil Design for Thermal Pads

- Reduce solder paste area by 20-50%
- Window panes are recommended
- How many bricks?
- Best width for webs, perimeters?

What about voids, float & bridging?

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Experimental Methodology

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Experimental Methodology

Thermal Pad Test Board
- D-Paks, QFN 10 mm, QFN 9 mm, QFN 7 mm, QFN 4 mm, QFP144
- FR4 0.062”, 1 oz copper, print and etch, ENIG finish

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Experimental Methodology

Stencils
- 50, 60, 70, and 80% area coverage on thermal pads
- Largest web, standard web, largest perimeter, most panes

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## Experimental Methodology

### Standard Design Parameters:

<table>
<thead>
<tr>
<th>Pad Dimension After Reduction</th>
<th>Web Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100 mils</td>
<td>None</td>
</tr>
<tr>
<td>101-150 mils</td>
<td>8 mils</td>
</tr>
<tr>
<td>150-200 mils</td>
<td>15 mils</td>
</tr>
<tr>
<td>&gt;200 mils</td>
<td>20 mils</td>
</tr>
</tbody>
</table>

What About Different Web Widths, # Bricks & Perimeter Spacing?

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# Experimental Methodology

<table>
<thead>
<tr>
<th>Paste Area (%)</th>
<th>Description / Design</th>
<th>Web Width (mils)</th>
<th>Perim. (mils)</th>
<th>Panes (#)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>Largest Web</td>
<td>34</td>
<td>1.6</td>
<td>4</td>
</tr>
<tr>
<td>80</td>
<td>Standard Web</td>
<td>20</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>80</td>
<td>Largest Perimeter</td>
<td>8</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>80</td>
<td>Most Panes</td>
<td>8</td>
<td>1.6</td>
<td>20</td>
</tr>
<tr>
<td>70</td>
<td>Largest Web</td>
<td>52</td>
<td>1.6</td>
<td>4</td>
</tr>
<tr>
<td>70</td>
<td>Standard Web</td>
<td>20</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>70</td>
<td>Largest Perimeter</td>
<td>8</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>70</td>
<td>Most Panes</td>
<td>8</td>
<td>1.6</td>
<td>49</td>
</tr>
<tr>
<td>60</td>
<td>Largest Web</td>
<td>36</td>
<td>1.6</td>
<td>9</td>
</tr>
<tr>
<td>60</td>
<td>Standard Web</td>
<td>20</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>60</td>
<td>Largest Perimeter</td>
<td>8</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>60</td>
<td>Most Panes</td>
<td>8</td>
<td>1.6</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>Largest Web</td>
<td>47</td>
<td>1.6</td>
<td>9</td>
</tr>
<tr>
<td>50</td>
<td>Standard Web</td>
<td>20</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>50</td>
<td>Largest Perimeter</td>
<td>8</td>
<td>38</td>
<td>9</td>
</tr>
<tr>
<td>50</td>
<td>Most Panes</td>
<td>8</td>
<td>1.6</td>
<td>144</td>
</tr>
</tbody>
</table>

QFN 10

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Experimental Methodology

Print and Stencil Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print Speed</td>
<td>50 mm/sec</td>
</tr>
<tr>
<td>Blade Length</td>
<td>300 mm</td>
</tr>
<tr>
<td>Blade Pressure</td>
<td>6.0 kg (0.20 kg/cm)</td>
</tr>
<tr>
<td>Separation Speed</td>
<td>3.0 mm/sec</td>
</tr>
<tr>
<td>Separation Distance</td>
<td>2.0 mm</td>
</tr>
<tr>
<td>Stencil Thickness</td>
<td>102 µm (4 mil)</td>
</tr>
<tr>
<td>Stencil Material</td>
<td>Standard SS 6-10 µm grain</td>
</tr>
<tr>
<td>Solder Paste</td>
<td>No clean SAC305 Type 4</td>
</tr>
</tbody>
</table>

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Experimental Methodology

Reflow Profile

<table>
<thead>
<tr>
<th>Setting</th>
<th>SAC305 RTS “linear”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Rising Slope</td>
<td>1.7 – 2.1 °C/sec</td>
</tr>
<tr>
<td>Soak Time (150-200 °C)</td>
<td>89 - 91 sec</td>
</tr>
<tr>
<td>TAL (Reflow time)</td>
<td>73 – 74 sec &gt; 218°C</td>
</tr>
<tr>
<td>Peak temperature</td>
<td>244 to 247 °C</td>
</tr>
<tr>
<td>Profile length (25 °C to peak)</td>
<td>4.6 minutes</td>
</tr>
</tbody>
</table>

Reflow Oven: 10 zone, reflow in air

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Experimental Methodology

Box Plots & Tukey-Kramer Honest Significant Difference

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Experimental Methodology

Process and Data

- Print Solder Paste
- Place & Reflow
- Take Pictures
- Tally Wet/Bridge
- Measure Voiding

Data

- 10 Boards Each
- 2 Stencils
- Inspection
  - Wetting / Solder Fillet
  - Bridging
  - Skew

- Voiding
  - Void Area %
  - Largest Void %

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D-Pak Components

- Voiding not able to be measured
- Wetting on the ground pad varied

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Voiding Results - Overview

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Voiding Results - Coverage

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Voiding Results - Stencil Design

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Voiding Results - Stencil Design

QFP144 Design

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Conclusions

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Conclusions

✓ QFN voiding is affected by stencil design and area of coverage
  • Standard window pane and largest perimeter give lowest voiding
  • 70-80% area gives lowest voiding

✓ QFP voiding is high enough to be unaffected by area or stencil design

✓ D-Paks were too dense for void measurement
  • 70-80% area was required to give full wetting of the ground pad

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Future Work

- Measure voiding: vary stencil thickness and overall paste volume
- Modify solder volume on QFN I/O (perimeter) pads and measure voiding
- Adjust stencil patterns and reflow profiles to minimize voiding

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