The Transition: Water Soluble to No-Clean Process Guidelines for Electronics Assembly

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Outline

- Process changes water soluble to no-clean
- Back to the basics
- Stencil printing
  - Paste measurement
  - Area ratio/transfer efficiency
  - Material attributes
- Reflow profile
  - Process guidelines
Transition Considerations (water-soluble to no-clean)

- Easy choice for cell phone manufacturers low reliability, high volume (throughput), low mix
  - Low reliability
  - High throughput
  - No inline cleaner

- Probe testing (ICT)
  - Some no-clean residues are easier to probe test than others

- Stencil design changes
  - Reduce paste volume solder balls/beads
Transition Considerations (water-soluble to no-clean)

- Component integrity (age)
  - Activity vs. Oxidation resistance

- Cleaning considerations
  - Will there be a need to clean the no-clean

- Rework
  - Compatibility
  - Use of liquid fluxes
  - Probe testability
Paste Print Characterization

Diagram showing factors influencing paste print characterization:
- **Human Interaction**
  - Time of Day
  - Shift
  - Time of Year
  - Age Related
  - Employee Ability Level
  - Employee Knowledge Level
  - Training
  - Operator Access to Printer/Reflow Settings
  - Employee Diligence

- **Environment**
  - Storage Temperature
  - Temperature Inside Printer
  - Relative Humidity
  - Time on Stencil
  - Mouse Heaping
  - Time Out of Cold Storage
  - Cold Storage Temperature
  - Time in Cold Storage
  - Air Movement Inside Printer

- **Solder Paste Material**
  - Date of Manufacture
  - Water Soluble
  - No Clean
  - tackiness
  - Viscosity
  - Metal %
  - Alloy
  - Powder Size
  - Shelf Life
  - Storage Orientation
  - Paste Properties

Factors affecting transfer efficiency and variation:
- **Design**
  - Stencil Type
  - Chemical Etch
  - Laser Cut
  - Electroformed

- **Printing Process**
  - Substrate Design
  - Squeegee Design
  - Pad Design
  - Aperture Count
  - Aperture Shape
  - Panel Length
  - Aperture Reduction
  - Conveyor Width
  - Aperture Patterns
  - Area Ratio
  - Stop Stencil
  - Surface Finish
  - Pad Spacing
  - Aperture Orientation
  - Pitch Dimension
  - Board Material
  - Pad Defined or Mask Defined
  - Pad Material

- **Tooling & Equipment**
  - Stencil Cleaning Frequency
  - Stencil Gating
  - Squeegee Speed
  - Squeegee Pressure
  - Separation Speed
  - Time Period Between Prints
  - Time Period Between Cleans
  - Units Between Clean Cycle
  - Dry Clean Cycle
  - Wet Clean Cycle
  - Amount of Paste on Stencil
  - Engraved Print Head
  - Overprint Distance

- **Transfer Efficiency & Variation**
Printing Critical to High Yields

- 60-70% solder defects occur at the printer
- Continual move towards miniaturization
- Paste measurement tools
  - Measure excessive and insufficient
  - Consistency pad to pad

**Target:** No outliers above 0.66 AR; No defect on first print after pause
Area Ratio and Transfer Efficiency

• Critical metric for paste print performance is the Area Ratio
  – The area of stencil aperture opening divided by the area of aperture side walls
  – Simplifies to D/4T (circles and squares)
  – > 0.66 widely accepted as industry standard
  – <0.66 stencil clogging

• Transfer Efficiency
  – Volume of solder paste deposited divided by the volume of the aperture (actual vs. theoretical)
## Area Ratio vs. Stencil Thickness

### Sample Area Ratio Chart

<table>
<thead>
<tr>
<th>Pad Size (mm)</th>
<th>0.05</th>
<th>0.10</th>
<th>0.15</th>
<th>01005</th>
<th>0.20</th>
<th>0.25</th>
<th>0201</th>
<th>0.30</th>
<th>0.35</th>
<th>0.40</th>
<th>0.45</th>
<th>0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture Width (mil)</td>
<td>2.0</td>
<td>3.9</td>
<td>5.9</td>
<td>7 x 8</td>
<td>7.9</td>
<td>9.8</td>
<td>10 x 12</td>
<td>11.8</td>
<td>13.8</td>
<td>15.7</td>
<td>17.7</td>
<td>19.7</td>
</tr>
<tr>
<td>Stencil Thickness (5.0 mil)</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.37</td>
<td>0.39</td>
<td>0.49</td>
<td>0.55</td>
<td>0.59</td>
<td>0.69</td>
<td>0.79</td>
<td>0.89</td>
<td>0.98</td>
</tr>
<tr>
<td>Stencil Thickness (4.5 mil)</td>
<td>0.11</td>
<td>0.22</td>
<td>0.33</td>
<td>0.41</td>
<td>0.44</td>
<td>0.55</td>
<td>0.61</td>
<td>0.66</td>
<td>0.77</td>
<td>0.87</td>
<td>0.98</td>
<td>1.09</td>
</tr>
<tr>
<td>Stencil Thickness (4.0 mil)</td>
<td>0.12</td>
<td>0.25</td>
<td>0.37</td>
<td>0.47</td>
<td>0.49</td>
<td>0.62</td>
<td>0.68</td>
<td>0.74</td>
<td>0.86</td>
<td>0.98</td>
<td>1.11</td>
<td>1.23</td>
</tr>
<tr>
<td>Stencil Thickness (3.5 mil)</td>
<td>0.14</td>
<td>0.28</td>
<td>0.42</td>
<td>0.53</td>
<td>0.56</td>
<td>0.70</td>
<td>0.78</td>
<td>0.84</td>
<td>0.98</td>
<td>1.12</td>
<td>1.27</td>
<td>1.41</td>
</tr>
<tr>
<td>Stencil Thickness (3.0 mil)</td>
<td>0.16</td>
<td>0.33</td>
<td>0.49</td>
<td>0.62</td>
<td>0.66</td>
<td>0.82</td>
<td>0.91</td>
<td>0.98</td>
<td>1.15</td>
<td>1.31</td>
<td>1.48</td>
<td>1.64</td>
</tr>
<tr>
<td>Stencil Thickness (2.5 mil)</td>
<td>0.20</td>
<td>0.39</td>
<td>0.59</td>
<td>0.75</td>
<td>0.79</td>
<td>0.98</td>
<td>1.09</td>
<td>1.18</td>
<td>1.38</td>
<td>1.57</td>
<td>1.77</td>
<td>1.97</td>
</tr>
</tbody>
</table>
Paste Measurement Gage R&R

- PTR (Precision Tolerance Ratio) less than 10% is excellent
- Newer paste measurement technologies 5% or less
Paste Handling

- **Storage (<10°C)**
  - No-clean chemistries on average have longer storage life

- **Room temperature storage of solder paste**
  - Once opened the shelf life is exacerbated by a number of variables

- **Temperature/Relative Humidity**
  - Water soluble chemistries are more sensitive to seasonal changes

- **Time on the stencil**
30-Day Room Temperature Stability

- Time = 0, 7, 14, 21, and 30 days @ 25°C (±1°C)
- Conditioned paste @ 30°C prior to viscosity testing
- Viscosity variation <5%, excellent stability

<table>
<thead>
<tr>
<th>Time (Days)</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>1747</td>
</tr>
<tr>
<td>T7</td>
<td>1800</td>
</tr>
<tr>
<td>T14</td>
<td>1820</td>
</tr>
<tr>
<td>T21</td>
<td>1668</td>
</tr>
<tr>
<td>T30</td>
<td>1679</td>
</tr>
</tbody>
</table>

Room Temperature Viscosity Per IPC-TM-650
(Test Method 2.4.34.3 - Malcom)
Transfer Efficiency Consistency

- More isn’t always better
  - Paste C greater average volume but less consistent
  - Paste A less average volume but more consistent
Water Soluble vs. No-clean

- Shelf and stencil life
- Printing results
  - Slump
  - Print definition
- Activity vs. oxidation resistance
Particle Size Print Results

Variability Gauge Component ID=S07_SMD
Variability Chart for Volume(%)
Circle vs. Square Apertures

- Comparison 14 and 15mil circles and squares
- Area ratio vs. volume for circle and square
SMD vs. NSMD (Copper Defined)

- SMD: solder mask defined
- NSMD: non-solder mask defined (pad defined)
- 8mil circles (4mil thick stencil)
- Increased surface area for solder paste adhesion
- Note that combination of SMD and square aperture, no outliers
Board support

- Solid landscape support with vacuum
- Board support total length of squeegee blade
- Board clamps vs. foiless clamps/snugger
- PWB to clamp height
Gasket/Registration

- Gasket of stencil to PWB is critical for ultrafine printing
- Stencil deflection
- Registration stencil aperture to PWB pad
Print Suggestions

- Unsupported squeegee blade leaves thin layers of solder paste
- Blade pressure
- Print speed
- Separation speed/distance
- Bead size
Stencil Technology

- Electroform
- Finer grain stencil materials
- Newer laser technology for cutting laser stencils
- Nano-coating
Max(+)slope

- Max (+) Slope 1.46°C/s
- Ambient to peak 4min 40s (280s)
- 1.46°C/s x 280s = 408.8°C increase from ambient to peak
- 25°C (ambient) + 408.8°C = 433.8°C peak
Average Ramp Rate

• Ramp rate is the average from ambient to peak (RTP profile)

• Ramp rate considerations for soak profile

• $214^\circ C/280s = 0.76^\circ C/s$
Profiling Suggestions

- Same delta between zone settings first few zones
  - i.e. 7 zone (110/130/150/170/190...last 2 for peak and TAL)
- Start 100-120°C (not too quickly or too slow)...alloy doesn’t change viscosity till melting point...flux every degree C
  - Slumping
  - Solder balls/beads
- Ramp to peak vs. soak
- Delta between TC’s peak and TAL
- 1°C ramp rate (not max(+)slope)
- Belt speed
- Soak parameters
QFN Voiding No-clean

- Condition paste room temperature storage, reflow at 7 and 14 days
- ImSn and CuOSP
- QFN56 and QFN88
- Fresh and oxidized (pre-treat onetime reflow)
Cleaning a No-clean

Cleaning Processes with Kyzen Cleaning Materials

Flux Removal in an Aqueous Cleaning Process

<table>
<thead>
<tr>
<th>Material Form</th>
<th>Wash Conc.</th>
<th>Wash Time</th>
<th>Wash Temp.</th>
<th>Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquanox A4625</td>
<td>RMA-SMQ51AC</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>NC-SMQ051SC</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>NC-SMQ090</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
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<tr>
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<td>NC-SMQ092</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>NC-SMQ092H</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>NC-SMQ230</td>
<td>Solder Paste</td>
<td>10-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>NC-SMQ92J</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>Indium8.9</td>
<td>Solder Paste</td>
<td>8-13%</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td></td>
<td>Indium8.9E</td>
<td>Solder Paste</td>
<td>10-13%</td>
<td>2-5 minutes</td>
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<tr>
<td></td>
<td>Indium8.9HF</td>
<td>Solder Paste</td>
<td>10-13%</td>
<td>2-5 minutes</td>
</tr>
</tbody>
</table>

Flux Removal in an Aqueous Cleaning Process:

<table>
<thead>
<tr>
<th>Inline Cleaning Process</th>
<th>VIGON® A 201</th>
<th>Indium5.1 Pb-Free Solder Paste</th>
<th>NC-SMQ 230 Pb-Free Solder Paste</th>
<th>NC-SMQ 921 Solder Paste</th>
<th>NC-SMQ 92H Solder Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc.</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>Conveyor belt speed</td>
<td>2.5 min.</td>
<td>2.5 min.</td>
<td>2.5 min.</td>
<td>2.5 min.</td>
<td>2.5 min.</td>
</tr>
<tr>
<td>Cleaning temperature</td>
<td>140°F / 60°C</td>
<td>140°F / 60°C</td>
<td>122°F / 50°C</td>
<td>122°F / 50°C</td>
<td>122°F / 50°C</td>
</tr>
<tr>
<td>Rinsing agent</td>
<td>DI-water</td>
<td>DI-water</td>
<td>DI-water</td>
<td>DI-water</td>
<td>DI-water</td>
</tr>
<tr>
<td>Drying</td>
<td>Circulating air</td>
<td>Circulating air</td>
<td>Circulating air</td>
<td>Circulating air</td>
<td>Circulating air</td>
</tr>
</tbody>
</table>
Rework

• Liquid Fluxes
  – Use of alcohol based
  – Wave fluxes
  – Materials that pass SIR without activation

• Tacky Fluxes

• Cored wire
Questions