Deposition of Solder Paste into High Density Cavity Assemblies

Fernando Coma
Jeffrey Kennedy
Thilo Sack
Aggressive space reduction and density increase.
Evaluate the practical limits of integrating PWBs with cavities into a standard IPC 610 Class 3 process
3 Solder Deposition Techniques which were evaluated:

- Step stencil
- Dispensing
- Jetting
test vehicle

Size: 185x60 mm
17 cavities

Cavity sizes (mm):

- 30 x 40
- 30 x 15
- 20 x 18
- 15 x 15
- 12 x 12
- 10 x 10
- 10 x 5
- 5 x 5
3 cavity depths

Cavities fabricated by AT&S (patented process)

Factors when choosing depth:
• Match the common thicknesses of SMT components
• Available pre-preg used in the stack-up of the PWB

Depths:
• 0 (TOP surface)
• 150 um
• 300 um
### 4 component types

<table>
<thead>
<tr>
<th>TYPE (inches/metric)</th>
<th>Density / Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>01005 (0402)</td>
<td>390 um</td>
</tr>
<tr>
<td>0201 (0603)</td>
<td>500 um</td>
</tr>
<tr>
<td>0402 (1005)</td>
<td>1 mm</td>
</tr>
<tr>
<td>CSP</td>
<td>300 um</td>
</tr>
</tbody>
</table>

For chip components, “density” is the minimum spacing between devices while for CSP’s, “pitch” if the device I/O minimum pitch evaluated.
1\textsuperscript{st} – step stencil

**Challenges:** Stencil manufacturing is key for this technology. Density into cavities is depending on stencil design.
stencil material used

- Fine grain stainless steel used for stencil

![Grain Size Comparison: SS 300 Series (Left) and New Material (Right)](image)

Std. 390 SS on Left and Fine Grain SS on Right
squeegees

**Challenges**: Alignment between blade and stencil. Cuts are needed to allow blade go into the cavities. Blade support used to increase pressure into cavities.
blade alignment: stencil & PCB

- Set up considerations
screen printer cycle

Screen printer video
blade support

- Using backside squeegee blade support improves print performance significantly
- However each cavity requires different amount of backside support

Without blade support

With blade support
trials

- Blade support to create pressure
- Blade behavior across the entire width of the board
- Transference into cavities [01005 (0402) / 0402 (1005) / CSP apertures]

Chip 0402 & 0201 volume

CSP Inside vs Outside of Cavity
results
step stencil summary

- Possibility of soldering all chip component types into cavities [includes down to 01005 (0402) sized chips]
- Able to accommodate different depth cavities, limitations comes from stencil manufacturing.
- Low cycle time as standard screen printer is used.
- More work required to support different depths and apertures in the same stencil.
2nd - dispensing

- Micro piston used dispenses a single shot per pump cycle.
- Able to dispense dots for 01005 (0402) components.
- Programmable to dispense at any height.
- Requires the use of special solder pastes designed for dispensing.
dedicated solder paste

Dedicated solder paste is required for this process as the head needs small particles, high flux content and special formulation to do the dispensing.

<table>
<thead>
<tr>
<th>Type 6</th>
<th>less than or equal to 5%</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 20um</td>
<td>5-20 um</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flux Content</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Percent</td>
<td>81 +/- 1%</td>
</tr>
</tbody>
</table>
dispensing machine cycle
• Parameters defined to dispense solder paste for 01005 (0402) component.
• Same parameters were used to dispense multiple dots for large parts.
• 0402 (1005) size pads needed up to 60 single dots.
dispensing summary

• Possibility of soldering all chip component types into cavities [includes down to 01005 (0402) sized chips]
• Able to accommodate different depth cavities without any restrictions.
• For production it is ideal to choose a machine that supports multiple dispense heads to reduce overall cycle time.
• Cycle time depends on the needle used to create dispensed dot sizes.
3rd - jetting

• Requires the use of special solder pastes designed for jetting.

• Minimum dot size able to be dispensed is 300um diameter [0201 components, (0603)] Impacts ability to handle smallest parts.

• Max. dispense height limits
Dedicated solder paste is required for this process as the head needs small particles, high flux content and special formulation to do the jetting.

% of Sample by Weight – Nominal Size

<table>
<thead>
<tr>
<th>Type</th>
<th>None Larger Than</th>
<th>Less Than 1% Larger than</th>
<th>90% Minimum Between</th>
<th>10% Maximum Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type5</td>
<td>30 Microns</td>
<td>25 Microns</td>
<td>25-15 Microns</td>
<td>15 Microns</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Flux Content</th>
<th>Metal Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type5</td>
<td>15.0 ± 0.5 (wt%)</td>
<td>85.0 ± 1.0 (wt%)</td>
</tr>
</tbody>
</table>
jetting machine cycle
3 heights tested

- Ideal dispense height above the board surface is 650μm, although increasing distance up to 850μm does not impact accuracy.
- Establishing datum to effectively jet into the cavities is critical (reference points)
- Assessed impact of dispensing into cavities from heights > 650μm on deposit consistency
jetting height vs positional accuracy

Comp 0201 (0603)
Cavity: 150um
Dispense height: 650um

Comp 0201 (0603)
Cavity: 150um
Dispense height: 1800um
## Capability Analysis for SN 396 P1 Volume 6.8 nl

### Summary Report

**How capable is the process?**

| Low | Z.Bench = 4.49 | High |

**Customer Requirements**

- Upper Spec: 1,156e+007
- Target: 6,8e+006
- Lower Spec: 3,4e+006

**Process Characterization**

- Mean: 5754349

### Does the process mean differ from 6800000?

**P1 (650 um)**

- V1 (6.8 nl) Cpk: 1.81 --- Ppk: 1.5
- V2 (51 nl) Cpk: 5.62 --- Ppk: 4.41

**P2 (950 um)**

- Cpk: 1.88 --- Ppk: 1.59
- Cpk: 6.26 --- Ppk: 3.84

### Are the data inside the limits and close to the target?

**Comments**

**Conclusions**

- The process mean differs significantly from the target ($p < 0.05$).
- The defect rate is 0.00%, which estimates the percentage of parts from the process that are outside the spec limits.

**Actual (overall) capability is what the customer experiences.**
flexibility
jetting summary

• Machine is capable for both processes (two head heights) and for different volumes (minimum 6.8 nl and maximum 51nl)
• IPC 610 Class 3 solder joints are achievable using jetting process for both 0402 (1005) and 0201 (0603) components
• Jetting machine is supposed to feed a pick and place machine mounting 40,000 components per hour. This data depends on the geometry of the PCB to be produced.
• Dispense strategy for each package can easily be controlled via simple software changes
• Standard jetting height is 650um, but working with the supplier this distance could be adapted to something less
summary

• Transferring solder paste into high density cavities is a process that can be done with high quality and capable of achieving IPC 610 class 3 standard solder joints.

• The most appropriate and cost effective method to use will depend on the final product configuration since each method did have its own limitations in terms of capability to support certain design features or cycle time.
recommended deposition method based on package type

<table>
<thead>
<tr>
<th>Package Type</th>
<th>01005</th>
<th>0201</th>
<th>0402</th>
<th>CSP 0.3</th>
<th>CSP 04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stepped Stencil</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Dispensing</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Jetting</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>
Several factors must be considered to integrate the most appropriate solder deposition method depending on product design and desired manufacturing setup.

### Process Decision Matrix

<table>
<thead>
<tr>
<th></th>
<th>Stepped Stencil</th>
<th>Dispensing</th>
<th>Jetting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment Investment</strong></td>
<td>XXX</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Manufacturing Cost</strong></td>
<td>XX</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td><strong>Cycle Time</strong></td>
<td>XXX</td>
<td>X</td>
<td>XX</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>X</td>
<td>XX</td>
<td>XXX</td>
</tr>
<tr>
<td><strong>Process Control</strong></td>
<td>X</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td><strong>Complexity</strong></td>
<td>X</td>
<td>XX</td>
<td>XXX</td>
</tr>
</tbody>
</table>

Note: X → Advantage, positive characteristic.
Acknowledgements

- Jeff Kennedy, Thilo Sack, Vicenta Jorge, Samuel Plasencia, Javier Canillas, Miguel Sanchez (Celestica), Euripides BOB Partners: Thales TCS & TGS, AT&S.
- Mydata / AB Electronics (Jetting)
- GPD (Dispensing)
- Great Lakes Engineering / Pantur (Stencils)
- Indium (Solder Paste)
Questions?