What’s Coming Down the Tracks for Printing and Stencils?

Presented by:
Chrys Shea, Shea Engineering Services

Expert Panelists:
Tony Lentz, FCT Companies
Mark Brawley, Speedprint
Jeff Schake, DEK-ASMPT
Topics and Format

30-minute presentation on

- New foil materials, mesh materials, high tension mounting, and nanocoatings
- New stencil cutting and stepping technologies
- New solder paste flux mediums, room temperature stability, and the trend toward finer solder powder types in response to miniaturization
- New hardware and software upgrades on stencil printing equipment

✓ Polls will be held during presentation to seek your input

30-minute round-table discussion

- Submit your questions online
- Direct to any individual or to the group

✓ Submit at any time during the presentation via box on your screen to the group or an individual
## Stencil Metal Foil Technology

<table>
<thead>
<tr>
<th>Metal Foil Technology</th>
<th>Grain Size</th>
<th>Minimum Area Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datum PhD foil “fine grain”</td>
<td>8-9 micron</td>
<td>0.55</td>
</tr>
<tr>
<td>Datum FG foil “ultra-fine grain”</td>
<td>1-2 micron</td>
<td>0.50</td>
</tr>
<tr>
<td>Datum Tension FG foil - New in the US</td>
<td>3-4 micron</td>
<td>????</td>
</tr>
</tbody>
</table>

Mill grade steel (500x)  
Datum PhD (500x)  
Mill grade steel (1000x)  
Datum FG (1000x)
Tension Foil Technology

- Cuts and prints like original FG, as seen above
- Cost competitive like PhD
- Higher tension mounting gives better snap off, more repeatable print process
- No spec on Fine Grain, beware of less expensive “fine grain” foils that do not cut or print as well as original
High Tension Foils and Frames

- Typical tension – 35-40 N/cm
- “High” tension – 50+ N/cm
- Promise to have less “snap back” and cleaner release
- Need a more rigid frame to carry higher tension without warping
- Needs stronger mesh to carry the tension without ripping
- May need a harder steel to carry higher tension on thin webs, hence the concept behind the Tension alloy

For excellent information on mesh and frame quality, see “A Different Perspective on Solder Paste Printing: Perfecting the Print Process with Practical Solutions” by Alison Buchholz of Panasonic, SMTAI 2015
Nano Coatings Repel Flux from Stencils

Flux Treated with UV Tracer Dye
10 prints with no wipe

Untreated side of stencil
Flux wicks out on the bottom surface away from the apertures

Treated side of stencil
Flux is repelled from the bottom surface and is contained primarily within the apertures
# Nano Coatings – 2 Basic Types

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Fluoro-Polymer</th>
<th>SAMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Spray and thermal cure</td>
<td>Wipe on</td>
</tr>
<tr>
<td>Applied by</td>
<td>Stencil supplier</td>
<td>Supplier or self</td>
</tr>
<tr>
<td>Thickness</td>
<td>2-4 µm</td>
<td>1-2 nm</td>
</tr>
<tr>
<td>Hydro- and oleophobic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Abrasion resistant</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chemical resistant</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Visible</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>Selected suppliers</td>
<td>Stencil suppliers or internet</td>
</tr>
<tr>
<td>Reworkable if worn off</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Reduces frequency of underside cleaning</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Solder paste volume</td>
<td>15 – 25% increase in TE</td>
<td>Slight decrease &lt; 5%</td>
</tr>
<tr>
<td>Aperture Redesign?</td>
<td>Maybe</td>
<td>No</td>
</tr>
<tr>
<td>Minimum Area Ratio</td>
<td>0.10 lower than foil</td>
<td>Same as foil</td>
</tr>
<tr>
<td>Cost</td>
<td>&gt;$100 supplier dependent</td>
<td>$20-50</td>
</tr>
</tbody>
</table>

**Fluoro-Polymer Coating**

**SAMP Coating**

(Self-Assembling Monolayer Phosphonate)
Nano Coatings and Transfer Efficiency

No Clean SAC305 Type 3 Solder Paste

Uncoated Datum PhD
Fluoro Polymer
SAMP - A
SAMP - D
Nanocoating vs. No Nanocoating

• Nanocoating is always better.  **ALWAYS**

• Videos at low ARs

<table>
<thead>
<tr>
<th>ARs</th>
<th>0.45</th>
<th>0.50</th>
<th>0.55</th>
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<th>0.70</th>
</tr>
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<td>180</td>
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<td>7.1</td>
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</table>

**Nanocoated**  **Not Nanocoated**
## Nanocoating Payback and Cost Savings Calculator

**Current First Pass Yield, %** 80  
**Savings per print** $0.35

**Projected First Pass Yield, %** 90  
**Cost of Nanoclear** $25.00

**% Improvement** 10%  
**Cost of Application** $20.00

**% of defects requiring simple rework** 90  
**Payback - # of Prints** 128

**% of defects requiring complex rework** 10

**Savings in Yield Improvement, per print** $0.35

### Quality

<p>| | |</p>
<table>
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<th></th>
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<tbody>
<tr>
<td>Current First Pass Yield, %</td>
<td>80</td>
</tr>
<tr>
<td>Projected First Pass Yield, %</td>
<td>90</td>
</tr>
<tr>
<td>% Improvement</td>
<td>10%</td>
</tr>
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<td>% of defects requiring simple rework</td>
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<td>% of defects requiring complex rework</td>
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**Savings in under wipe consumables, per print** $0.005

### Productivity

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<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Wipe Frequency</td>
<td>5</td>
</tr>
<tr>
<td>Projected Wipe Frequency</td>
<td>10</td>
</tr>
<tr>
<td>% Reduction</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Savings in under wipe consumables, per print** $0.005

### Cost Reduction

<p>| | |</p>
<table>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Cost of simple rework</td>
<td>$1.20</td>
</tr>
<tr>
<td>Cost of complex rework</td>
<td>$24.00</td>
</tr>
<tr>
<td>Cost of wiper paper, per wipe cycle</td>
<td>$0.03</td>
</tr>
<tr>
<td>Cost of solvent, per wipe cycle</td>
<td>$0.02</td>
</tr>
</tbody>
</table>

**Annual Cost Reduction** $87,984

**Annual Savings per SMT Line**

<p>| | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td># of prints per hour</td>
<td>60</td>
</tr>
<tr>
<td># of production hours per week</td>
<td>80</td>
</tr>
<tr>
<td># of paper roll changes per week</td>
<td>10</td>
</tr>
<tr>
<td>Time to change wiper roll, minutes</td>
<td>5</td>
</tr>
</tbody>
</table>

**Annual Cost Reduction** $87,984

**Additional Production Uptime, hours per year** 43

**Additional PCBs assembled per year** 2600

**Download workbook from:**
- www.globalsmt.net
- www.sheaengineering.com
- www.aculon.com

Modify cost information on the "Cost Calculator" tab.
Laser Cutting

- Produces most accurate stencils
- Stencil quality depends on machine quality, age, calibration, maintenance
- Newer cutters have very fine laser beams, on-board optical inspection to make sure the hole is fully cut, on-board aperture measurement for SPC, and remote control for cals, tune-ups or troubleshooting
- Ask your stencil vendor about his cutter – brand, model, calibration and PM history

Image source: www.tannlin.com
Stepping

Stepping is critical in many processes, especially when stencil design calculations are being performed based on aperture volumes and area ratios

• Steps can be chemically etched, milled, or welded prior to laser cutting

• Step Types:
  – Step Up: Thickens stencil locally
  – Step Down: Thins stencil locally
  – Top or Bottom side steps, or both
  – Multi-level steps: Accommodate more component variety/needs
  – Angled steps: Reduce squeegee damage (also w/encl print heads)
  – Cavity relief: For labels or other PCB topographical features

• Precision steps are often required for high-density assemblies

• Milling Machines are now available to create steps
Laser Cut and Welded Steps

Manufacturing Process:

- Laser cut of required size of step area
- Welding process of an accurate fitted step in desired thickness
- Cutting of apertures in step area and stencil

User Benefits:

- Exact thickness and surface roughness
- Highest precision in stencil step technology
- Can step up/down on same stencil and still maintain surface quality
- Can create stencils for cavity PCBs

Pioneered by LaserJob; now available at shops with Tannlin T11 laser cutters
Solder Paste Developments

• New lead-free formulations release really well
• Introduction of room-temp stable pastes
  – Holy Grail for years
  – Within certain temperature parameters (<40°C/104°F)
  – Always tradeoffs in paste properties
• Videos of solder paste release
• T4 powders replacing T3 as new standard. T5?
• No-Clean vs. Water Soluble and why people are choosing to clean no-cleans
**Solder Paste Elasticity**

**Square vs. Circle: What releases better?**

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*Uncoated stencil, Paste C*
Dirty vs. Clean – Uncoated Stencil

• “Dirty” condition is 4\textsuperscript{th} print without wipe
  – Not an exceptionally long wipe interval
• “Clean” condition is 1\textsuperscript{st} print after solvent wipe
  – 5 prints before wipe to get squeegee in right position

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Dirty

Clean
Dirty vs. Clean – Nanocoated Stencil

- Lower ARs
- No discernable difference in release in this comparison

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Solvent vs Dry Wipe on Nanocoated Stencil

Solvent Wipe

Dry Wipe

Tests were performed using wipe-on (SAMP) nanocoating with solder paste treated with UV tracer dye and a black light to show the flux smearing.
Solder Paste Powder Types – When to Switch?

IPC-7525B  2011-October.  Stencil Design Guidelines

3.2.1 Aperture Size.  A typical guideline is a minimum of 4 to 5 particles of paste powder across the width of an aperture.

<table>
<thead>
<tr>
<th>Type</th>
<th>Mesh</th>
<th>Size (µm)</th>
<th>Size (mil)</th>
<th>Min Aperture Size (mil)</th>
<th>AR with 5 mil Stencil</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-200/+325</td>
<td>45 - 75</td>
<td>1.8 - 3.0</td>
<td>15.0</td>
<td>0.75</td>
</tr>
<tr>
<td>3</td>
<td>-325/+500</td>
<td>25 - 45</td>
<td>1.0 - 1.3</td>
<td>9.0</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>-400/+635</td>
<td>20 - 38</td>
<td>0.8 - 1.5</td>
<td>7.5</td>
<td>0.38</td>
</tr>
<tr>
<td>5</td>
<td>-500/+800</td>
<td>15 - 25</td>
<td>0.6 - 1.0</td>
<td>5.0</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Solder Paste Powder Types and TE%

- Uncoated Datum PhD
- No Clean SAC305 Types 3, 4, and 5

T4 -> T5: Don’t do it to try to fix process problems!!!
Printability

• Generally speaking, each generation of solder paste prints better than its predecessor
  – Newer formulations print better than older ones
  – Lead-free pastes are newer formulations than most tin-leads; therefore lead-free products generally print better than tin-lead

• Generally speaking, no-clean pastes are have longer stencil lives and wider process windows than water-soluble
  – There are exceptions to the rule
Solder Paste Chemistry and TE%

- Uncoated Datum PhD
- All Type 3 Powder

LF T4 has best process window. Most WS need cleaning chemistry anyway so assemblers are cleaning their no-cleans.
Printer Hardware & Software

- Enclosed Print Head improvements
- Meshless mounted stencils
- Compliant Pin tooling is proliferating
- Self-adjusting squeegee deflectors take operator influence out of the process
- Bead height monitor
- Autoset snuggers
- Improved closed-loop feedback from SPI
- New paper more effective and compatible with nanocoatings
- Paste and adhesive dispenser built into printer
Auto Height Adjusting Snugger Clamp

1. PCB loads, clamp measures PCB thickness

2. Clamp retracts to PCB height, pinches PCB sides

3. PCB raised to aligned contact with stencil apertures; clamp type allows unobstructed printing to PCB edges

4. Some systems now include integrated vacuum to improve stencil gasketing
Consumable Product Developments

• Patterned hydrophilic fabric roll improves paste particle capture
• Low linting, non-abrasive structure
• Excellent for preserving nanocoating finishes

• Quick roll changeover design reduces line down time
• Lateral oscillation during travers
• Programmable high flow vacuum & engineered solvent dispense
Advanced Closed Loop Feedback

- Solder Paste Measurement + Expert System
- Automatic printing machine program optimization
- Self learning capability
- Continuous printing production quality monitoring & machine parameter control
- Intelligent cleaning cycle optimization.
Advanced Dispense Unit

Dispenses Paste and Glue

- Single or Dual Head
- Paste/Adhesive (any dispensable materials)
- Easy Programming
Advanced Dispense Unit

Auto dispense programming on any rotation

Cleaning & Calibration station
Advanced Dispense Unit Video

Full video available at: https://www.youtube.com/watch?v=3eKhkJ__CnY
Questions for Panelists?

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