Pin-in-Paste Process Webcast

March 22, 2001

Presented By:
Surface Mount Technology Laboratory

- David Vicari
  Process Research Engineer

- Wilhelm Prinz von Hessen
  Manager, Customer Process Support

- Jim Adriance
  Process Research Engineer
Introduction

Greg Reed
Editorial Director
EP&P
Pin-in-Paste or Alternative Assembly and Reflow Technology (AART)
Definition of AART

The use of mass solder reflow technology for the attachment of through-hole and odd-form components.

Successful implementation depends on:
- Wetting ability of the flux vehicle
- Wetting characteristics of the leads and the printed circuit board
- Reflow profile
Definition of Odd-Form Components

Odd-Form Component:
Odd shape through-hole or surface mount components that cannot be automatically placed using standard pick and place assembly machines due to the component’s height, shape, or weight.

- Computer
  - PCI slot
  - D-sub/audio jacks
  - DIMM socket

- Automotive
  - Connector
  - Connector

- Telecommunications
  - Phone jack
  - MICTOR
Typical Assembly Solution

- Printing
- High Speed Placement
- Flexible Placement
- Odd form Component Placement
- Solder Reflow

[Image of printing high speed placement flexible odd form component solder reflow solutions]
Driving Forces and Benefits

- **Component availability**
  - Not all through-hole parts available as surface mount technology

- **Reliability**
  - For connector applications with high end-user use versus a surface mount technology joint

- **Cost reductions via:**
  - Reduction of labor costs
    - Manual soldering personnel
    - Equipment operators
    - Maintenance technicians
  - Elimination of process steps
    - Soldering operations
    - Cleaning
      - Dross elimination
  - Elimination of capital equipment/materials
    - Wave solder machine(s)/Fluxing, cleaning solvents
Overview

- Considerations for AART
- Process sequence
  - Paste deposition
  - Component insertion/placement
  - Reflow soldering
- Solder volume calculations
- Reliability
- Conclusion
Considerations for Implementing AART

Properties of reflow compatible through-hole components

- High temperature housing
- Lead/Pin metallurgy
- Variety of lead finishes
- Lead cross-section and design
- Component standoff
- Lead length
- Lead pitch
- Row spacing
- Row configurations
  - Inline
  - Staggered
Considerations for Implementing AART

- Component Materials
  - Reflow compatibility
Considerations for Implementing AART

Materials

- Components
  - Standoff
  - Standoff location
  - Lead length

![Image of electronic components with labeled parts: Standoff, Lead length, Leads, and Standoff]
Considerations for Implementing AART

Materials

• Components
  • Standoff location
Considerations for Implementing AART

Materials

- Components
  - Locating features
Considerations for Implementing AART

Design
- PCB
  - Thickness
  - Solderable features
- Stencil thickness

Process
- Solder deposition method
  - Stencil
- Placement equipment
  - Nozzles, vision systems, grippers
- Reflow profile
  - Component compatibility, flux activation
Overview

• Considerations for AART
• Process sequence
  • Paste deposition
  • Component insertion/placement
  • Reflow soldering
• Solder volume calculations
• Reliability
• Conclusion
Process Sequence

- Solder Paste Deposition
- Component Insertion/Placement
- Reflow
Solder Paste Deposition - Stencil Printing

Stencil Printing (typical)

Double Stencil Print (thin / thick)
Step Stencil
Solder Paste Deposition - Dispensing

Typical Solder Interconnection after Process Optimization
**Solder Preforms**

Readily available standard and custom shapes

**Considerations include the following:**

- Pre-fluxed deposits or solid solder
- Standoff height
- Preassembled to component or pick and place
- Proper geometry
Component Insertion/Placement

Automatic
- Vacuum nozzle
- Mechanical grip
- Vision/Non-Vision

Manual
- Speed/Repeatability
- Accuracy
- Orientation
Reflow Soldering

- Forced convection
- IR
- Combination forced convection/IR

Typical Reflow Profile for SN63 Solder Paste

- Wetting Time: 30-60 Sec.
- Flux Activation/Dryout
- Reflow
- Cooling

Temperature °C vs. Time (Seconds)
Reflow
Reflow Profile Development
Reflow Profile Development
Reflow Profile Development

Reflow profile must provide adequate time for:

- Flux volatilization
- Pullback
- Proper peak temperatures
- Time above liquidous
Overview

• Considerations for AART

• Process sequence
  • Paste deposition
  • Component insertion/placement
  • Reflow soldering

• Solder volume calculations

• Reliability

• Conclusion
Solder Volume Calculations

Anatomy of a Through-Hole Solder Joint

- Top Fillet Volume
- PTH Volume
- Bottom Fillet Volume
Solder Volume Calculations: Fillets

Top and bottom fillet area can be calculated using the $A=0.215r$.

Fillet area can then be rotated about the center of gravity to obtain the fillet volume.

A simpler method to approximate the volume required for the Top and Bottom fillet area is to treat it as a Frustum of a cone.

$$V = 0.2618h \left( D^2 + Dd + d^2 \right)$$
Factors significantly affecting hole fill

- Squeegee angle
- PTH diameter
- Type of squeegee
- Print speed
- Board thickness
Solder Volume Calculations: Solder Paste Hole Fill

AART Solder joint with 20% hole fill

AART Solder joint with 100% hole fill
Decision Support System

The “AARTIST” also includes a ‘Comprehensive Decision Support System’ which integrates the ‘Individual Intelligent Agents’

The ‘Individual Intelligent Agents’ are:

• Hole Fill Predictor - predicts the percentage of hole fill for a given set of print parameters
• Solder Volume Estimator - estimates the solder paste volume to be deposited for an individual component
• Stencil Aperture Design Assistant - provides assistance in designing the stencil apertures for an individual component
• Print Parameter Estimator - helps to determine print parameters for a given hole fill percentage
Solder Volume Calculations: Solder Paste Hole Fill

Sample calculation #1

[Diagram showing estimated hole fill percentage with input parameters such as solder type (Polyurethane), print pressure (0.33-1.26 lb/inch), print speed (0.63-0.7 inches/sec), etc., and resulting predicted hole fill percentage of 70.64%.]
Solder Volume Calculations: Solder Paste Hole Fill

Sample calculation #2
# Solder Volume Calculations: Solder Paste Hole Fill

## Sample calculation #3

<table>
<thead>
<tr>
<th>Value of Input Parameters</th>
<th>Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste Type</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Print Pressure</td>
<td>0.13-1.26 lb/inch (0.11-0.22 kg/cm)</td>
</tr>
<tr>
<td>Print Speed</td>
<td>0.14-1.02 inches/sec (24-240 mm/sec)</td>
</tr>
<tr>
<td>Squeeze Angle</td>
<td>45</td>
</tr>
<tr>
<td>Hole Size (in inches)</td>
<td>0.142</td>
</tr>
<tr>
<td>Board Thickness (in inches)</td>
<td>0.162</td>
</tr>
</tbody>
</table>

The predicted hole fill percentage is 96.30%
Solder Volume Calculations: Solder Paste Hole Fill

Sample calculation #4

[Image of a calculation tool with input parameters and results]

The predicted hole fill percentage is 101.02%.
Solder Volume Calculations: Solder Paste Hole Fill

Critical issue for thick boards
• >70 mil
• High solder paste volume requirement
• Significant amount needed in PTH

Modifications in stencil printing parameters
• Double squeegee stroke
• Reduced squeegee angle

Pro-flow head - another solution
Solder Volume Calculations: Total Volume Requirements
Aperture Design Considerations

Factors that influence aperture design:

• Proximity to other components and wettable surfaces (ie., test points, vias, etc.)
• Component configuration
  – Lead pitch
  – Row spacing
  – Row configurations
    • Inline
    • Staggered
• Accurate solder volume calculation
• Stencil thickness
• Hole-fill estimate
Aperture Design Considerations

Stencil aperture design and orientation influences hole-fill

An example: Uneven hole-fill is a possibility
Solder Volume Calculations: Aperture Design

![Screenshot of a software interface for calculating solder volume in a stencil design. The interface shows fields for shape of aperture, length, breadth, required aperture volume, actual aperture volume, hole fill volume, volume accommodated by this design, and percentage of ideal solder paste volume requirement.]
Solder Volume Calculations: Aperture Design

Proper aperture design results in:

- High assembly yields
- Quality solder joints
Overview

- Considerations for AART
- Process sequence
  - Paste deposition
  - Component insertion/placement
  - Reflow soldering
- Solder volume calculations
- Reliability
- Conclusion
Reliability of AART Soldered Joints

• Accelerated life testing
  • Thermal shock testing (MIL-STD-883, Method 1011.6)
    – Air-to-air thermal shock
    – Temperature range: -55°C to 125°C
    – Dwell time at each temperature extreme: 10 min.
    – 1000 cycles

• Daisy-chained resistance measurements

• Comparative study of wave-soldered, no-clean, and water soluble reflowed soldered joints

• Statistical analysis of reliability results

• Failure analysis of AART boards (no failures up to 800 cycles)
Reliability of AART Soldered Joints

Wave soldered joint after 1000 thermal cycles

AART soldered joint after 1000 thermal cycles
Overview

- Considerations for AART
- Process sequence
  - Paste deposition
  - Component insertion/placement
  - Reflow
- Calculations
- Reliability
- Conclusion
  - Critical success factors
  - Summary
  - Questions and answers
Critical Success Factors

- Accurate estimation of solder paste volume
- Accurate prediction of solder paste hole fill
- Well controlled stencil print process
- Excellent solder paste characteristics necessary (no solderballing, good pullback, low slump, etc.)
- Temperature compatible components with necessary standoff and low reveal length
- Accurate and repeatable component insertion process
- Careful attention to reflow profile
- DFA/DFM principles need to be applied
Summary

• High-yield process and reliable solder interconnections within reach

• AART process is compatible with existing processes and industry-wide infrastructure

• Potential throughput increase while subsequently reducing product cost

• Can be introduced as a “drop-in” process into existing lines with minor modifications to materials and machines
Contact Information

Wilhelm Prinz von Hessen  
Manager, Customer Process Support  
Universal Instruments Corp.  
(607) 779-4970  
vonhesse@uic.com

David Vicari  
Process Research Engineer  
Universal Instruments Corp.  
(607) 779-5151  
vicari@uic.com

George R. Westby  
Director Area Array Consortium  
Director SMT Laboratory  
Universal Instruments Corp.  
(607) 779-5258  
westby@uic.com
Question and Answer Session

Don’t miss additional Webcasts sponsored by EP&P and Universal:

• Flip Chip Assembly (June 2001)
• Optoelectronics (September 2001)
• Manufacturing Automation Software (November 2001)

For more information on Technology Seminars sponsored by Universal Instruments, please visit our Web site: