Vi Technology

3D Solder Paste Inspection Solutions

New Opportunities for Solder Paste Inspection
Demands of 3D SPI

- Smaller and finer-pitch components like 01005 and flip-chip
- Higher popularity of components with invisible joints like CSP and BGA
- Higher opportunity of defect occurrence by lead-free solder paste (low wetting force, poor self-align characteristics, different aperture to pad ratio etc)
- Higher soldering quality required in mobile and security industry
- Approx. 70~80% of PCBA defects result from solder paste
- Repair cost reduction
- Defect prevention by process control

![Graph showing defect portion of total process and repair cost per defect]

- Screen printing: 0-20%
- Component mounting: 0-10%
- Reflow soldering: X 10

Repair cost per defect: X 10
Defect portion of total process: 70-80%
Effects of 3D SPI

Through 3D measurement of paste volume, height, area and position

(Providing important predictor of good quality and long-term reliability of solder joints)

- Saving repair cost by earlier defect detection
- Preventing defects by feed-back & control of screen printing process
- Increasing long-term reliability of solder joint by solder volume control
Flying Absolute Height Profilometry (FAHP)

- Laser Triangulation
  - Laser Diode
  - CCD
  - Viewing Lens
  - PCB

- Moire Interferometry
  - White Light
  - Viewing Lens
  - Projection Lens
  - PCB

**FAHP**
- On-the-fly Scan
- Fast inspection Speed
- Wider height measurement range
- No vibration noise
- Repeated Move & Stop
- Slow inspection speed
- Limited height measurement range
- Vibration noise

**Epoch-making 3D Measurement Method combining only merits each from Laser Triangulation and Moire interferometry**
- Low resolution
- Low accuracy
- Sensitive to surface reflection property
- High resolution
- High accuracy
- Less sensitive to surface reflection property

- Agilent Technology
- GSI Lumonics
- Orbotech
- Koh Young
- Cyber Optics
- CKD

TECHNOLOGY
QUALITY INVESTMENT FOR PROCESS CONTROL
FAHP PRINCIPLE (Absolute Height Measurement)

1. $\phi = f^{-1}(I)$ (I = Intensity, $\phi$ = Phase)

2. $\phi_{\text{absolute}} = \phi + n \cdot 2\pi$ ($0 < \phi < 2\pi$)

3. $n = f(\phi_1, \phi_2)$

$n$ times wider measurement range
without degrading resolution.

$h_{\text{absolute}} = f(\phi_{\text{absolute}})$

$\phi_{\text{absolute}} = \phi + n \cdot 2\pi$ ($0 < \phi < 2\pi$)
ALGORITHM

SURFACE PLANE WITH SLOPE

Solder Paste
Reference
PCB

COMPARISON W./W.O SLOPE

WITHOUT SLOPE COMPENSATION

WITH SLOPE COMPENSATION
FAHP
(FLYING ABSOLUTE HEIGHT PROFILOMETRY)

PSMI
(PHASE SHIFT MOIRE INTERFEROMETRY)

Move ‘HEAD’
STOP ‘HEAD’
MOVE ‘GRATING’
STOP ‘GRATING’
Capture Image

Calculate Phase

Calculate Height

ON THE FLY
REPEATED MOVE & STOP

N TIMES?
no
yes

ON THE FLY
REPEATED MOVE & STOP

INSPECTION SPEED SOLUTION
No Shadow effect

- Zero % shadow effect by structured double light sources
- No volume measurement error apart from pad orientation
Assumption I. QFP BUMP CASE.  
(Parallelepiped Bump Shape)
L=2mm, W=0.5mm, H=0.12mm

Assumption II. CSP BUMP CASE.  
(Cylindrical Bump Shape)
D=0.3mm, W=0.5mm, H=0.12mm

(1) Angle 0°
Shadow Area : 0.18mm² (18%)

(2) Angle 45°
Shadow Area : 0.16mm² (16%)

(3) Angle 90°
Shadow Area : 0.45mm² (4.5%)

Shadow Area : 0.027mm² (38%)
True Volume Measurement

1. 3D bare board measurement.

2. 3D total measurement of ROI. 3. Extraction of bare board geometry.

4. Solder paste volume only.
### Measurement Description (1)

**Area**
- **Measurement object**: Stencil Area from Gerber File
- **Reference value**: 1
- **Measurement**: Summing all pixels of solder paste area.
- **Equation**: $X = \sum \text{One pixel dimension} \times \text{Total pixel number of solder paste area}$

**Volume**
- **Measurement object**: Stencil Area X Stencil thickness
- **Reference value**: 1
- **Measurement**: Summing each pixel's volume of solder paste area.
- **Equation**: $X = \sum (\text{One pixel dimension} \times \text{Height of pixel area})$

**Height**
- **Measurement object**: Stencil thickness
- **Reference value**: 1
- **Measurement**: Averaging Top 50% height (AHR 50%)
- **Equation**: Height = Average($h_{(i,j)}$) for Solder Area
# Measurement Description (2)

<table>
<thead>
<tr>
<th>Item</th>
<th>Measurement object</th>
<th>Reference value</th>
<th>Measurement</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge</td>
<td>![Bridge Diagram]</td>
<td>Bridge Length</td>
<td>![Bridge Measurement]</td>
<td>Connectivity between neighboring solders</td>
</tr>
<tr>
<td>Shape</td>
<td>![Shape Diagram]</td>
<td>Convex solder</td>
<td>![Shape Measurement]</td>
<td>Ratio=$\frac{\text{Volume (Measured)}}{\text{Volume (Convex hull)}}$</td>
</tr>
</tbody>
</table>
Operation flow

Gerber based pad programming → Teach & edit → Inspection

Off-line SPC → Defect review
3D Solder Volume Functionalities

- Inspection tests
  - Insufficient or excessive height and volume
  - Position shift
  - Area
  - Abnormal shape
  - Bridge

- Offline conversion of Gerber and CAD Data
- On-machine defect review
- Real-time process monitoring and alarm signal generation
- Real-time SPC software for process monitoring and defect analysis
3D Solder Volume Performances

- Typical inspection speed @ zero shadow effect mode
  - Satisfying most line cycle times in the market
  - 20 cm²/sec @ zero shadow effect mode
- Perfect shadow effect elimination
  - Structured dual light source inspection mechanism
  - No volume measurement errors due to pad orientation
- High repeatability
  - < 10% GR&R for every solder pastes with 30-50% tolerance
  - Height < 1.5µm (3σ) on standard certification target
- High accuracy
  - Height < 3µm on standard certification target
  - Height Resolution : 0.1µm
- PCB warp measurement & measurement compensation
  - Upward 3.0mm / downward 3.0mm without z-axis control
PCB Warp Measurement

Note: Data collected from PDP PCB of S Company
Fast Programming from Gerber & CAD

PAD LEVEL PROGRAMMING.
(Typically 5 minutes)

- Gerber file import
- Automatic pad information input
- Inspection parameters input
- Debug & Automatic training
- OK?
- Start production

COMPONENT LEVEL PROGRAMMING.
(Typically 30 minutes)

- CAD file import
- Semi-automatic component information input
- Link pads with component
Off-line SPC Station

- Chart Samples

- X-bar / R Chart.
- Scatter Chart.
- Raw Data List.
- Capability Chart.

- X-bar / S Chart.
- Trend Chart.
- Raw Data Expert.
- X-bar Distribution Map
- Other Chart Etc.