Non-Destructive Inspection Method of BGA Using X-ray Systems for High-Density Mounting Space Applications

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Outline

• Background
• Major Defects of BGA
• Inspection Method
• Results
• Summary
• Tasks
• Recently, demands of high-density mounting technique for miniaturization of space applications have increased.

• We are considering to apply BGA packages to space applications as a solution of high-density mounting.

• A critical issue of BGA package is that inner balls cannot be inspected by a conventional visual inspection method.

• In these circumstances, we focus on inspection methods of BGA using X-ray systems.
**Major Defects of BGA**

**In-line defects**

- Ball Misalignment
- Non-reflow
- Non-wetting
- Open
- Scratch
- Solder Ball Dispersal
- Ball Shape Defect
- Excessive Solder
- Solder Bridge
- Missing Ball
- Void

**End-of-line defect**

- Crack
Inspection Method

BGA Samples

- Plastic BGA (388pin)
  - Number of Layers: Six Layers
  - Pattern: Daisy Chain
  - Pitch: 1.27mm
  - PWB Material: FR-4
  - PWB Size: 77.5mm(W) X 120mm(D) X 1.6mm(T)

- Metal BGA (560pin)
  - Substrate: PWB
  - Eutectic (63Sn/37Pb)
  - Metal heat sink: (Cu)
  - Layer: 0.9mm

- Ceramic BGA (400pin)
  - Substrate: PWB
  - Eutectic (63Sn/37Pb)
  - High melt (90Pb/10Sn)
  - Layer: 0.75mm
  - Eutectic (63Sn/37Pb)
## Inspection Method (cont.)

### Specification of X-Ray Systems

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Microfocus X-ray(I.I.)</th>
<th>Microfocus X-ray(FCR*)</th>
<th>Microfocus X-ray(FPD**)</th>
<th>3-D X-ray CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray tube</td>
<td>Sealed X-ray tube</td>
<td>Open type X-ray tube</td>
<td>Sealed X-ray tube</td>
<td>Open type X-ray tube</td>
</tr>
<tr>
<td>X-ray detector</td>
<td>Image Intensifier</td>
<td>Imaging Plate</td>
<td>Flat panel (Six megapixels)</td>
<td>Flat panel (Six megapixels)</td>
</tr>
<tr>
<td></td>
<td>(I.I.)</td>
<td>(IP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray-scale</td>
<td>256 gray-scale</td>
<td>1024 gray-scale</td>
<td>4096 gray-scale</td>
<td>4096 gray-scale</td>
</tr>
<tr>
<td>Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Focal spot size : 7µm</td>
<td>Focal spot size : 1-4µm</td>
<td>Focal spot size : 1-4µm</td>
<td>Focal spot size : 1-4µm</td>
</tr>
<tr>
<td></td>
<td>Tube voltage : 150kV</td>
<td>Tube voltage : 100-120kV</td>
<td>Tube voltage : 100-120kV</td>
<td>Tube voltage : 100-120kV</td>
</tr>
<tr>
<td></td>
<td>Tube current : 66µA</td>
<td>Tube current : 100-150µA</td>
<td>Tube current : 100-150µA</td>
<td>Tube current : 100-150µA</td>
</tr>
<tr>
<td>Image processing</td>
<td>Digital image processing</td>
<td>Digital image processing</td>
<td>Digital image processing</td>
<td>Digital image processing</td>
</tr>
</tbody>
</table>

* FCR : Fuji Computed Radiography (FUJI PHOTO FILM CO., LTD)
** FPD : Flat Panel Detector

![FCR System](http://www.oe.nagoya-denki.co.jp(contents/products/nlx/NLX5000e_forweb.files/index.html)
# Results

## Result

<table>
<thead>
<tr>
<th>No.</th>
<th>Defect Item</th>
<th>Apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I.I.</td>
</tr>
<tr>
<td>1</td>
<td>Ball Misalignment</td>
<td>***</td>
</tr>
<tr>
<td>2</td>
<td>Non-reflow</td>
<td>***</td>
</tr>
<tr>
<td>3</td>
<td>Non-wetting</td>
<td>***</td>
</tr>
<tr>
<td>4</td>
<td>Open</td>
<td>***</td>
</tr>
<tr>
<td>5</td>
<td>Scratch</td>
<td>***</td>
</tr>
<tr>
<td>6</td>
<td>Solder ball dispersal</td>
<td>**</td>
</tr>
<tr>
<td>7</td>
<td>Ball shape Defect</td>
<td>***</td>
</tr>
<tr>
<td>8</td>
<td>Excessive Solder</td>
<td>***</td>
</tr>
<tr>
<td>9</td>
<td>Solder Bridge</td>
<td>***</td>
</tr>
<tr>
<td>10</td>
<td>Missing Ball</td>
<td>***</td>
</tr>
<tr>
<td>11</td>
<td>Void</td>
<td>**</td>
</tr>
<tr>
<td>12</td>
<td>Crack(CeramicBGA)</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Crack(Plastic/MetalBGA)</td>
<td>*</td>
</tr>
</tbody>
</table>

- ***: Detectable
- **: Depend on position
- *: Undetectable
- ---: N/A

### In-line defects

### End-of-line defects
Example of In line Defects

- Solder ball dispersal (Metal BGA)

**Solder balls of 30um in diameter were detectable clearly by microfocus x-ray.**
Results (cont.)

Example of In line Defects (cont.)

- Void (Plastic BGA)

<table>
<thead>
<tr>
<th>Detectable</th>
<th>Detectable</th>
<th>Detectable</th>
<th>Detectable</th>
</tr>
</thead>
</table>

- It is possible to know the void position using 3-D X-ray CT.
Example of End-of-line Defect

- **Crack (Plastic BGA)**

<table>
<thead>
<tr>
<th>Undetectable</th>
<th>Detectable</th>
</tr>
</thead>
</table>

Microfocus X-ray (FCR)  | 3D X-ray CT  | DPA

Crack size is 13um.

**3-d X-ray CT allows us to detect the crack which is undetected by microfocus X-ray.**
Crack of Ceramic BGA was detected by both microfocus X-ray and 3-D X-ray CT.
• **Capability of 3D X-Ray CT System**

  Microfocus X-ray (FCR)

  3-D X-ray CT

  *Detectable*

  Horizontal image 1
  Horizontal image 2
  Horizontal image 3

  Vertical Image 1
  Vertical Image 2
  Vertical Image 3
Results (cont.)

- Capability of 3D X-Ray CT System (cont.)

Summary

• In-line defects of BGA can be detected by microfocus X-ray(I.I./FCR/FPD) or 3-D X-ray systems.

• It is possible to detect solder cracks by 3-D X-ray CT system.

• We hope that X-ray inspection is an effective way to evaluate the quality of BGA assembly when applied for space applications.
Tasks

- Evaluation of X-ray inspection capability on an actual flight module or a test vehicle.

- Upgrading and expanding of our design rules of PWB for BGA mounting.
今回報告したBGAの非破壊検査技術をまとめた技術資料がございます。ご興味のある方は下記メールアドレスに氏名、会社名、住所、連絡先（電話、FAX、E-mail）、ご意見・ご要望等をお送りください。

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