“Innovative Socket Technology For 0.3mm Pitch BGA Devices”
Ila Pal — Ironwood Electronics, Inc.

“Socket Performance Over Time And Insertion Count With Pb-Free Applications”
Jeff Sherry, Bert Brost — Johnstech International Corporation

“A Case For Socket Reuse – An Approach To Managing The Cost Of High-End Burn-In Sockets”
Paul Gaschké, Dave Carpentier — IBM Systems and Technology Group
Innovative Socket Technology for 0.3mm Pitch BGA Devices

ILA PAL

Agenda

- Packaging roadmap
- 0.3mm pitch BGA package
- Socket mounting background
- Socket design
- Embedded wire in elastomer
- Experiments
- Results
- Conclusions
**Packaging Roadmap**

Source: Hitachi review volume 48

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**Packaging Roadmap**

Source: Hitachi review volume 48
Packaging Roadmap

0.3mm Pitch BGA Package

1. Dimensions are in millimeters.
2. Interpreted dimensions and tolerances per ASME Y14.5M-1994.

Dimension b is measured at the maximum solder ball diameter, parallel to datum plane Z.

Datum Z (seating plane) is defined by the spherical crowns of the solder balls. Parallelism measurement shall exclude any effect of mark on top surface of package.

<table>
<thead>
<tr>
<th>DIM</th>
<th>MIN</th>
<th>MAX</th>
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<tbody>
<tr>
<td>A</td>
<td>0.44</td>
<td></td>
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<tr>
<td>A1</td>
<td>0.085</td>
<td>0.115</td>
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<tr>
<td>B</td>
<td>0.165</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3.744</td>
<td>3.944</td>
</tr>
<tr>
<td>E</td>
<td>4.922</td>
<td>5.032</td>
</tr>
</tbody>
</table>

95 Solder Balls
All dimensions are in mm
Socket mounting background

- Fastener mount
- Solder mount
- Epoxy mount

Fastener mount socket
**Fastener mount socket**

- Solder-less socket
- Easy assembly and disassembly
- No rework cost
- Backing plate provides stiffness and rigidity
- Keep-out area is still a significant % of overall package area
- Requires through holes in PC board

**Solder mount socket**

[Diagram of solder mount socket with labels for SCREW, ALUMINUM WALL, ALUMINUM FLOATING PLATE, BGA IC PACKAGE, ALUMINUM COVER, FR4-PCB MATERIAL, ELASTOMER, SOLDIER SPHERE, and SCREW]
Solder mount socket

- Assembled using standard reflow method
- Very difficult to disassemble
- More rework cost
- Target PCB has to be thicker to provide stiffness and rigidity
- Keep-out area is a large % of overall package area
- Requires no through holes in PC board

Device area and Keep-out area
Comparison of mounting configurations

- Fastener-mount
- Solder-mount

Device area (mm x mm)

Keep-out area (mm x mm)

BGA devices in Cell Phones

- Signal processors
- SRAMs
- Flashs
- ASICs
- Other devices
- ......
BGA devices in Cell Phones

- How much keep out area is allowed to mount a socket?

Epoxy mount socket

- SCREW
- ALUMINUM COVER
- BGA IC PACKAGE
- SCREW
- EPOXY
- DOUBLE SIDED TAPE
- ELASTOMER
- FR4 ALIGNMENT PLATE FOR BGA
- ALUMINUM FLOATING PLATE
- ALUMINUM WALL
**Epoxy mount socket**

- Requires no through holes in PC board
- Requires no soldering onto PC board
- Target PCB has to be thicker to provide stiffness and rigidity
- Keep-out area is a very minimal % of overall package area
- Very difficult to rework and disassemble

### Comparison of mounting configurations

![Graph comparing mounting configurations](image)

- Fastener-mount
- Solder-mount
- Epoxy-mount

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March 12 - 15, 2006
Socket Design

F₁ = force needed to compress the device
F₂ = epoxy retention force per square mm
F₂ = f/A
f = epoxy retention force
A = surface area

Safety design recommends:

\[ f = 1.5F₁ \]
\[ AF₂ = 1.5F₁ \]
\[ A = 1.5F₁/F₂ \]
Embedded wire in elastomer

Experiment

Paper #1

March 12 - 15, 2006
Results

Conclusions

- Epoxy mount socket requires minimal keep out area
- Properly designed socket was epoxy mounted on many handheld PCBs for failure analysis
- Elastomer contact was successfully tested for 0.3mm pitch BGA devices
- This concept was tested on peripheral devices (QFN) also
Thank You
Socket Performance Over Time and Insertion Count With Pb-Free Applications

2006 Burn-in and Test Socket Workshop
March 12 - 15, 2006

Bert Brost and Jeff Sherry
Johnstech International

Agenda

• Package I/O Plating and Composition
• SnPb Performance and Repeatability
• Pb-Free Performance Issues
• Contact Plating and Composition
• Effects of Pb-Free Device Plating
  – Matte Tin
  – NiPdAu
• Device I/O Surface Oxide Penetration and Removal
• Conclusions
Package I/O Plating and Composition

- Type of package
  - Pad vs. Leaded vs. BGA vs. Other
- Device plating effects - Oxide formation
  - Lead-based vs. Lead-free
- Effects of tolerances
- Size of pads and pitch
- Type of device being packaged
  - RF, amplifiers, digital, mixed signal
- Debris generated
  - Sawed vs. Molded vs. Broken

Package I/O Plating and Composition

- Matte Tin (very high percentage of Pad and Leaded packages)
- NiPdAu (small percentage but growing – harder smoother surface)
- SnAgCu (mostly BGA devices – SAC305)
- SnBi (used mostly in Japan)
- Au
- Other Sn based materials
  - SnCu
  - SnAg
  - SnNi
SnPb Performance and Repeatability

NOTE: Same contacts and elastomers were used on the entire test, surrogate devices replaced every 100K insertions

BiTS 2006 Presentation – Socket Design

Pb-Free Performance Issues

- More oxidation on leads or pads on Sn
  - More false failures
  - More contact cleaning / maintenance
  - Higher contact forces
- Different companies have different solutions – no standardization yet
Contact Plating and Composition

Contact Plating and Composition

BiTS 2006 Presentation – Socket Design

BiTS 2006 Presentation – Socket Design

Contact Plating and Composition

Handler Data for Standard vs. Corner Contact With 100% Matte Tin

<table>
<thead>
<tr>
<th>Contact Type</th>
<th>Avg (mOhms)</th>
<th>Std Dev (mOhms)</th>
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</thead>
<tbody>
<tr>
<td>Pad Corner Contact</td>
<td>18.35</td>
<td>2.90</td>
</tr>
<tr>
<td>Pad Middle Contact</td>
<td>20.72</td>
<td>4.35</td>
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<tr>
<td>Polished Corner Contact</td>
<td>19.67</td>
<td>1.84</td>
</tr>
<tr>
<td>Polished Middle Contact</td>
<td>18.76</td>
<td>2.08</td>
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</table>

Matte Tin Effect on Contact Location and Smoothness

Paper #2

March 12 - 15, 2006
Contact Plating and Composition

Contact Resistance over life. No cleaning or maintenance with 90/10 solder plating on test vehicle.

Effects of Pb-Free Device Plating – Matte Tin

SnPb - 1.6 Million insertions  Matte Tin - 300K insertions
Effects of Pb-Free Device Plating – Matte Tin

Standard ROL100 Contact Profile After 1 Million Insertions

<table>
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<tr>
<th>Feature Label</th>
<th>Nominal</th>
<th>Actual</th>
<th>Upper</th>
<th>Lower</th>
<th>Deviation</th>
<th>Out Tol</th>
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<tbody>
<tr>
<td>Profile</td>
<td>0.065</td>
<td>0.072</td>
<td>0.085</td>
<td>0.051</td>
<td>-0.013</td>
<td>-0.025</td>
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</table>

No cleaning performed during test

Effects of Pb-Free Device Plating – Matte Tin

Lead 2mm Contact Resistance for Various Contacts and Platings

* Contacts Replaced Every 300K Insertions
Effects of Pb-Free Device Plating – Matte Tin

Leaded 4mm Contact With Different Device Platings

Contact Resistance in mOhms

Number of Insertions in Thousands

Effects of Pb-Free Device Plating – NiPdAu

Contact Resistance for Different Platings and Cleaning Cycles

Number of Insertions in Thousands
Effect of Pb-Free Device Plating – NiPdAu

Pad ROL200 Series Contact Resistance - Full Tip With NiPdAu Plating

No cleaning was performed during test

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Average Contact Resistance</td>
<td>10.40 mOhms</td>
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<tr>
<td>Std. Deviation in Contact Resistance</td>
<td>2.52 mOhms</td>
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<tr>
<td>Corner Pin Yield</td>
<td>99.85%</td>
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<tr>
<td>Middle Pin Yield</td>
<td>99.996%</td>
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Device I/O Surface Oxide Penetration and Removal

SnPb - 1 Insertion  SnPb - 10 Insertions  SnPb - 50 Insertions

Device I/O Surface Oxide Penetration and Removal

SnPb Plating  Matte Tin Plating

50X and 1 Insertion  20X and 1 Insertion
Device I/O Surface Oxide Penetration and Removal

- NiPdAu 100X 1 Insertion
- Matte Tin 20X 1 Insertion

Device I/O Surface Oxide Penetration and Removal

- NiPdAu Package 1 Insertion
- NiPdAu Package 50 Insertions
Conclusions

- There are many Pb-Free platings with each having different benefits
- More plating oxides generally result in more cleaning of contacts to maintain performance
- Matte Tin plating is inexpensive, but because of oxides, results in higher contact resistance and may not be the best choice for resistance sensitive devices
- Harder plating results in lower contact life
- Some Pb-Free platings require more force to break through oxides
- Self cleaning wipe function is critical to long-term Pb-free performance
A Case for Socket Reuse
An Approach to Managing the Cost of High-End Burn-In Sockets

Burn-in and Test Socket Workshop
March 12 - 15, 2006

Paul Gaschké
Dave Carpentier
IBM

Agenda
An Approach to Managing the Cost of High-End Burn-In Sockets

• What Drives the Cost?
• What Can be Done to Manage the Cost?
• A Flexible Socket Design is a Must
What Drives the Cost?

- High current contacts
  - 4+ amp continuous per pin 1mm clustered
    - Sympathetic heating from adjacent contacts
  - Low and stable contact resistance
- High contact count
  - 1,000 to 2,000 per socket

What Drives the Cost?

- High clamping force
  - To compress 1,000 to 2,000 contact populations
  - Lead free BGA
    - High psi to make reliable contact
- Thermal Management
  - Integrated heat sinks
  - Integrated heaters
  - Thermal feedback
What Drives the Cost?

- Large product sizes
  - 45mm+
  - Molding large arrays is more difficult
    - May drive more machined parts
    - Larger tolerances
- Supply and demand
  - Limited solutions can drive up cost

What Can be Done to Manage the Cost?

Socket Reuse

- Cost of ownership
  - A simple calculation of the cost over time
  - Each reuse would include a reconfiguration cost

<table>
<thead>
<tr>
<th></th>
<th>Initial use</th>
<th>1st reuse</th>
<th>2nd reuse</th>
<th>3rd reuse</th>
<th>4th reuse</th>
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<tbody>
<tr>
<td>Cost of Sockets</td>
<td>100%</td>
<td>50%</td>
<td>33%</td>
<td>25%</td>
<td>20%</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>20%</td>
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</tbody>
</table>
What Can be Done to Manage the Cost?

Socket Reuse

• Compression mount
  – Key technology
    • A must for socket reuse
  – Improved board and tester utilization
    • 100% functional sockets per board
    • Possible reduction of testers and boards
  – Serviceability
    • Failed socket positions can quickly be repaired
    • Sockets have better probability of being repaired

What Can be Done to Manage the Cost?

Socket Reuse

• Other considerations
  – Quick socket configurations can enable early or specialized test which can be a business advantage
  – Common hardware
    • More inventory may enable economies of scale
    • Socket cost can amortized over many years
A Flexible Socket Design is a Must
An Example of a Design Approach

- Two part design
  - Contactor
  - Clamp
    - Patent 5,748,007

Clamp Sub-Assembly
A Flexible Socket Design is a Must

- Ability to adapt to product height variations
  - Thickness
    - Tolerance
  - Materials
    - Ceramic
    - Organic
  - Topography
    - Chip
    - Capacitors
    - Lids
Alignment and Centering Plates
A Flexible Socket Design is a Must

• Ability to adapt to product alignment variations
  – LGA / BGA
    • Nest
    • Corner
    • Center

Alignment and Centering Plates
A Flexible Socket Design is a Must

• Ability to adapt to varying compression forces
  – Contacts
    • Quantity
    • Force
  – Springs
    • Quantity
    • Force
Clamp Sub-Assembly
A Flexible Socket Design is a Must

• Accommodate thermal management features
  – Open top
    • Convective
  – Heat sinks
    • Passive
    • Active
    • External
Clamp Sub-Assembly
A Flexible Socket Design is a Must

• Ability to accommodate various contactor sub- assemblies
  – Adapt to LGA, BGA, lead free, etc.
  – Adapt to varying pitch and count
  – Adapt to different electrical performance requirements

Contactor Sub-Assembly
A Flexible Socket Design is a Must

• Ability to reuse contacts
  – Some high power contacts are very expensive
    • Reuse is virtually a must.
  – Can be the primary cost driver
• Ability to re-populate custom arrays
  – Reuse contactor housing
  – Ease of loading is a plus
  – On site maintenance and repair is a plus
Contactor Sub-Assembly
A Flexible Socket Design is a Must

• Test both BGA and LGA with same contact?
  – A plus for expensive contacts
• Ability to contact even, odd, and mixed arrays
  – Common housing design

Last Consideration

• Managing socket reuse overhead
  – Configuration, repair, quality control, etc.
    • User managed
      – Significant training
      – Significant inventory/document management
      – Test equipment
    • Vendor managed
      – User need only enough spares to maintain 100% utilization
      – Minimal user training and inventory management
      – No test equipment
In Closing

• Demanding test specifications have increased socket costs
• Reuse can manage these costs
• A highly configurable socket design enables an efficient reuse strategy

Questions