Session 6
New Technologies
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Presentations

“Using MicroSpring™ Contacts As Second Level Interconnect”
John Novitsky
FormFactor

“A New Burn-in Socket For Fine Pitch BGAs”
Yuji Wada Akio Hasebe Kenichiro Morinaga
Hitachi Ltd. Hitachi Ltd. Hitachi Ltd.

Hideo Arima Hiroyuki Mogi Hokuto Kanesashi
Hitachi Ltd. Enplas Corporation Enplas Corporation

Tomoaki Soshi
Enplas Corporation

“Novel Contacting Technology For Fine Pitch Leaded & Area Array Devices”
Frank Bumb Ron Revell
3M 3M
Using MicroSpring™ Contacts as Second Level Interconnect

BiTS Workshop
Mesa, Az.
28 February 00

John Novitsky
VP Business Development
925-456-3850  jnovitsky@formfactor.com
Primary Invention:
MicroSpring™ Contact

1. Bond and shape a gold wire to form a spring “skeleton”.

2. Patented wire cut process for z axis planarity.

3. Overcoat the “Skeleton” with a spring alloy to form a MicroSpring Contact.
Two Business Models

<table>
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<tr>
<th>Product</th>
<th>IP Licensing</th>
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<tr>
<td>Probe Cards</td>
<td>WOW/MOST</td>
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<td>Sockets</td>
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</tbody>
</table>
**Probe Card: for C4 Balls or Al Pads**

- **MicroSpring™ probe elements:**
- **Space Transformer with Microspring™ probes**
- **MicroSpring contactors on x32 Memory Probecard**
- **Resilient Microspring Interposer:**
- **3-pt Planarizer**
- **Controlled Impedance tester interface PCB Assembly**
C4 Probe Cards
Wire-bond Probe Cards
Field Performance of Probe Cards

- FFI Probe Cards have been in the field for ~4 years
- Most heavily used Probe Cards have seen over 2 Million touchdown cycles (@ 5 Mils deflection), with no abrasive cleaning performed, and no measurable wearout mechanism.
  - FFI Probe Cards now ship with a lifetime warranty.
  - Probe Cards contain an “interposer”. This two-sided interposer is a wiping, Au on Au pad on ceramic on the top, and wiping Au on Au pad on PCB on the bottom. CRES remains stable over the life of the cards, so FFI has high confidence that the MicroSpring contact used as a second level interconnect is inherently stable.
Variables of MicroSpring Contacts

- **Spring shape:**
  - Height, length: determine wipe motion, influence resiliency, influence elec-specs
  - Cross section: round wire or ribbon wire: influence durability, elec-specs

- **Metalurgy:**
  - Overplating metals: influences durability, long term reliability/stability, k-value

- **Tips:**
  - Shape, materials: influences initial CRES and lifetime durability, required cleaning processes and cycles, determines pad metalurgy

- **# Contacts/pad**
  - Redundant contacts used in some applications

- **Pitch:**
  - C4 Probe Cards in production at 9 mil area array pitch
  - DRAM Probe Cards (Al WB pads) in production at <5 mil pitch
  - Sockets min pitch estimated around 15 mils
MicroSpring Contacts on Silicon

Wafer Covered with MicroSpring Contacts

2-Sided Module Soldered with MicroSpring Contacts
MOST
MicroSpring Contacts on Silicon

Process Overview:
- Fabricate MicroSpring contacts onto Si Wafer
- Handle and test as whole wafers, or as singulated ICs
- Solder, or socket, to PCB modules

Benefits:
- Very low cost CSP (<$0.005/lead)
- Very low cost and scalable back-end test and handling costs
- Industry’s highest demonstrated CSP reliability
- Demonstrated high performance

Note: the MicroSpring contact is used both as the temporary compliant interface to IC test equipment, and as the interconnect from the IC to boards, blurring the historical distinction between first and second level interconnect.
MOST WLBI Clamp and Contactor
MOST Sockets
MicroSpring Contacts in Burn-in

- Socket, for this application, means an x-y registration frame with a hold-down lid.
- FFI is doing its most extensive burn-in characterization for the purposes of qualifying MicroSpring contacts on Silicon wafers (MOST).
- Two forms of BI contactors have been built, and are being commercialized:
  - a wafer level BI contactor that mates to a wafer full of MOST contacts.
  - a BI/test socket for singulated die with MOST contacts. Both Yamaichi and Aehr have demonstrated forms of these sockets.
FFI Socket Strategy

- Apply MicroSpring™ Contact Technology, Production Proven in FormFactor’s Industry Leading Wafer Probe Cards
- License to High Volume Sockets Suppliers

<table>
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<th>LGA</th>
<th>BGA</th>
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<tr>
<td>Production Sockets</td>
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<td></td>
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<tr>
<td>Bring-up Sockets</td>
<td></td>
<td>x</td>
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</table>
Cross Section of Socket

- Floating “pin protector”, aligns package, protects contact tips, acts as positive compression stop.
- Solders directly onto BGA pattern.
- Footprint compatible between Engineering bring-up socket, and production socket.
- When socket no longer desired, simply solder BGA in place.
- A family of standard body sizes & pitches is being developed, to be compatible standard packages.
Example 1: 2mm Socket Stackup

Contactor: 35 Mils (compressed)

PCB: 25 Mils
Soldered Balls: 20 Mils

Total: 80 Mils

Scrub: ~8 Mils
Coplanarity/Compliance: 8-10 Mils
+ 2-3 Mils with ‘Set’
MicroSpring™ Contact Array
Wiping Au Tip on Au Pad

Au Spherical Tip

Scrub Mark on Au Pad
Example 2: 0.7 mm Socket Stackup
0.7mm Socket Stackup

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<th>Before Attach</th>
<th>After Soldering</th>
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<tr>
<td>Contact:</td>
<td>33 Mils</td>
<td>21 (compressed)</td>
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<tr>
<td>Substrate:</td>
<td>3 Mils</td>
<td>3 Mils</td>
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<tr>
<td>Solder:</td>
<td>6 Mils (stencil print)</td>
<td>1 Mil</td>
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<tr>
<td>Pad:</td>
<td>1 Mil</td>
<td>1 Mil</td>
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<tr>
<td>Total:</td>
<td>43 Mils</td>
<td>26 Mils (0.7mm)</td>
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<tr>
<td>Scrub:</td>
<td>~ 6 Mils (measured)</td>
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<td>Compliance:</td>
<td>~ 12 Mils (measured)</td>
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<td>Series Resistance:</td>
<td>~ 9 mOhms (measured)</td>
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<tr>
<td>Inductance:</td>
<td>~0.62nH (simulated)</td>
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</table>
0.7mm MicroSpring Contacts
Additional Contact Shapes
CRES “Knee of the Curve” ~5 Grams
MicroSpring Contactor Hertzian Stress Exceeds Minimums for Reliable Lifetime Contact
MicroSpring Force Deflection Curve
10 cycles / 15 mils maximum deflection
MicroSpring™ Contactor Life Testing
5000 cycles/5 mil max deflection
MicroSpring Contacts are Reliable

- Two subsets of EIA 701 have been run, and passed, in 1998.
- Interposers used in FFI probe cards since 1996, with no problems.
- Tyco Tests Performed, and *Passed*:  
  - Temp Life
  - Mixed Flowing Gas
  - Insulation Resistance
  - Thermal Cycling, Humidity Cycling: (in process)

- White Paper available from Tyco or FFI
MicroSpring Contact Socket Benefits

- **Reliable at Low Force, Low Height**
  - 10g/pin, +/- 2x. Min Stackup @ 20 mils.
  - Ideal for portable electronics, or for high pin count packages.

- **Up to 15 mils of Compliance**

- **Durability of Thousands of Cycles @ 10 mils**
  - Millions of cycles at 5 mils

- **Easily scales to 0.5mm pitch**
  - Max array size 100 mm x 100mm (today)

- **Manufacturing Friendly System**
  - Substrate prevents solder wicking, BGA balls simplify alignment, MicroSpring compliance reduces rejects
  - Any solderable surface on the Motherboard, compatible with normal BGA
  - Wiping contact improves initial mating success
  - Floating pin protector protects tips, provides positive compression stop for efficient heat sinking
  - Compatible between BGA/LGA bring-up socket, LGA production socket, limited test LGA socket
MicroSpring Socket Summary

- MicroSpring Contacts are being used in:
  - BGA and LGA bring-up sockets
  - LGA production and test sockets
- MicroSpring sockets are the Industry’s:
  - lowest force, lowest profile, and finest pitch socket system
  - highest compliance socket system
- FFI is in the business of licensing the contact technology to high volume sockets makers
  - Contact Tyco Electronics for samples, production, or quotes
A NEW BURN-IN SOCKET FOR FINE PITCH BGAs

Yuji Wada, Akio Hasebe, Kenichiro Morinaga and Hideo Arima
Assembly Technology Development Operation Semiconductor Integrated Circuits, Hitachi Ltd.

And

Hiroyuki Mogi, Hokuto Kanesashi Tomoaki Soshi
Semiconductor Peripherals Div., Enplas Corporation

02/29/2000
Agenda

• Market Trend
• Technical Issue and Its Countermeasure
• Socket Technology
  – Projected Formed Contact Technology
  – Reduction of Solder Ball Deformation
  – Absorption for Uneven Solder Ball Height
  – Accurate Alignment of Socket Assembly
  – Tape Circuit Fanned-out
• Socket Cost Reduction
• Future Development
• Conclusion
Market Trend

LOGIC SOCKET

QFP

BGA

CSP-0.8

MEMORY SOCKET

TSOP

CSP-0.8/-0.75

CSP-0.5mm pitch SOCKET

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Market Trend
Current Socket Design for CSP 0.5 mm Pitch

Sheet Rubber Type

Spring Probe Pin Type

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Technical Issue and Its Countermeasure

Technical Issues

• Reliable & economical contact for less than 0.5 mm pitch is not yet established.
  – Longer Life Cycle after Burn-in (125 deg. C.)
  – Less Solder Ball Deformation after Burn-in (125 deg. C.)
  – Absorption for Uneven Solder Ball Height
  – Accurate Precise Alignment of Socket Assembly

• Difficulty of BIB Design Followed by Package Fine Pitch Tendency
Technical Issue and Its Countermeasure

Countermeasures

• Development of Highly Reliable Contact
  – Projection Formed Contact Technology
    » Longer Life Cycle
  – Polyimide Stopper
    » Less Solder Ball Deformation
  – Appropriate Contact Force & Elastomer
    » Absorption for Uneven Solder Ball Height
  – Multiple Layered Method
    » Accurate Socket Assembly
• Tape Circuit Fanned-out
  » Applicable with Current BIB Technology
- 2 Layered Wiring
- Polyimide Stopper
- Elastomer
Socket Technology

- Projection Formed Contact Technology
- Reduction of Solder Ball Deformation
- Absorption for Uneven Solder Ball Height
- Accurate Alignment on Socket Assembly
- Tape Circuit Fanned-out
Socket Technology
Projection Formed Contact Technology

- To Realize Solder Ball Self-alignment
- To Realize Longer Contact Life by Designing Edge Contact
- To Absorb Uneven Solder Ball Height by Increasing and Standardizing Edge Contact Height

Edge Contact
Principle of 4 probe method
Socket Technology
Engineering Data

Transition of Contact Resistance after 125deg.-C for 1000hours
New Socket Technology
Engineering Data

Transition of contact resistance (Ω/pin)

- Developed Socket
  - Solder: 64Sn-36Pb
- Socket for 0.8mm pitch/48pin BGA
  - Solder: Sn-Ag-Cu

Result of Evaluation for Contact lifetime
1 Cycle; 100 mechanical actuation + 8 hrs/125deg.-C

0.167 Ω
Socket Technology
Reduction of Solder Ball Deformation

• By using polyimide stopper, even Sn/Pb solder ball can be minimized. Pb free solder ball can be more minimized.
Socket Technology
Reduction of Solder Ball Deformation

POLYIMIDE STOPPER

POLYIMIDE STOPPER
Transition of bump height Data (w/ and w/o Polyimide Stopper)

Transition of bump height at 150deg.-C

Solder 64Sn/36Pb

N=10 Package
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<tr>
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<th>stopper</th>
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<td><strong>150deg.-C for 1h</strong></td>
<td><img src="image1.png" alt="Image 1" /></td>
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**solder : 64Sn/36Pb**
## Assembly Reliability

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<th>150deg. - C for 2h</th>
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![Cross section of mounted CSP256pin](image)

02/29/2000
Socket Technology
Absorption for Uneven Solder Ball Height

- Appropriate Contact Force
- Elastomer Application
Socket Technology
Accurate Alignment on Socket Assembly

• Accurate alignment on socket assembly can realize by using multiple layer method.
Socket Technology
Tape Circuit Fanned-out

- Fanned-out Tape Circuit can realize to apply current BIB technology. (0.5mm pitch 1.27mm pitch)
Socket Cost Reduction

- By increasing varieties of Tape circuit, alignment plate, and pad, this socket can widely apply with variety of BGA package. (288 pin at maximum)
Socket Cost Reduction
Series Lineup

• BGA-288-0.5 Series
• BGA-288-0.4 Series Plan
• BGA-420-0.5 Series Plan
• BGA-420-0.4 Series Plan
• BGA-676-0.5 Series Plan
• BGA-676-0.4 Series Plan
## Socket Cost Reduction
### BGA-288-0.5 Series Lineup

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02/29/2000
Future Development

• Applicable with LGA Package.

• Applicable with Future Market Demands of High Pin Count & Fine Pitch (0.3 & 0.4 mm pitch).

• More Cost Reduction by Realizing Multiple package / Tape Circuit per Socket

• Application for Test Socket
Conclusion

• Development of Highly Reliable Contact
  – To Realize Longer Life of Contact
  – To Minimize Solder Ball Deformation
  – To Absorb Uneven Height of Solder Ball
  – To Improve Accurate Alignment on Socket Assembly by Applying Multiple Layered Socket

• Applicable with Current BIB Technology
• Socket Cost Reduction(Increasing Varieties of Tape Circuit, Alignment Plate, & Pad)
• Applicable with LGA & Future Market Demands(High Pin Count & Fine Pitch)
Novel Contacting Technology for Fine Pitch Leaded & Area Array Devices

Frank Bumb
Product Development Manager
Phoenix, AZ

Ron Revell
Laboratory Manager
Austin, TX
Outline

• The Problem
  – Pitch
  – Signal Integrity
• Design Objectives
• Design Features
• Design Evaluation
The Problem
IC Package Trends

HIGH PIN COUNTS

DIP

SOJ

TSOP

LOGIC

Area Array Mount

Peripheral Mount

MEMORY

QFP

PBGA

TBGA

CSP

FBGA

1.00mm
0.80mm
0.75mm
0.65mm
0.50mm

CSP:
:Chip Size Package

FBGA:
:Fine pitch BGA

TBGA:
:Tape BGA

PBGA:
:Plastic BGA

Electronic Handling & Protection Division

3M Innovation

BIT 2000 Revell.ppt
3M BGA/LGA SOCKET

1.50/1.27mm Clam-Shell

1.27mm Open-Top

0.8X1.0mm for RDRAM

1.00mm Clam-Shell

1.00mm Open-Top

0.80mm Open-Top

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SOCKET CONSTRUCTION

Physical

Body:
- Material: Polyethersulfone (PES)
- Flammability: UL 94V-0
- Color: Black

Alignment Plate:
- Material: Liquid Crystal Polymer (LCP)
- Flammability: UL 94V-0
- Color: Black

Contact:
- Material: Beryllium Copper
- Plating: Gold over Nickel

Other Metal Parts:
- Material: Stainless Steel

Marking:
- 3M Logo / Textool Logo
- Pin #1 Indicator / Part No.
CONTACT CONCEPT

CONTACT MARK

* With Micro Wiping

CONTACT

SOLDER BALL

F_R = F_L

150 degree C. 48hrs.

125 degree C. 48hrs.

Solder Ball Deformation of 1.27mm O/T

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Pitch Reduction

Technology Drivers

Size reduction
device size
lead pitch
area array

Signal integrity
processor speed
voltage level
voltage margin

Wafer Level Process

Lead spacing (mm)

Mold, Stamp, Assemble Technology

“The edge of current technology”

New technology required

Source: Nat'l Tech Roadmap for Electronic Interconnection (97)

Electronic Handling & Protection Division
Signal Integrity Drivers

Source: Nat'l Tech Roadmap for Electronic Interconnection (97)

Electronic Handling & Protection Division

3M Innovation
Current Technology Limitations

Complex shape for mechanical properties

Long signal path = high inductance

Parallel shape = high capacitance

This contact is 2X size needed

Very thin material limited strength
Why New Technology?

- Limitations of Mold-Stamp-Assemble (MSA)
  - Physical size
    - Fabrication
    - Assembly
  - Strength of materials
  - Electrical performance
    - Inductance
    - Resistance
    - Interconnect resistance
New Technologies

- Miniaturized standard technologies - stampings & pogo pins
- Columns of coiled wire
- Wires in elastomer or epoxy
- Columns of electrodeposited fibrous metal in elastomer
- Columns of particles in elastomer
- Flex circuits with particles & bumps with elastomer backing
MicroTouch™
High Performance Testing Solutions

Electronic Handling & Protection Division

3M Innovation
Design Objectives

• Size
• Signal Integrity
• Mechanical Durability
MicroTouch™ Products
Characterization to Final Test
MicroTouch™ Automation
Design Features

• Contact Mechanism
• Signal Path
• Adaptability
MicroTouch™
Compliant Leads

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3M Innovation
MicroTouch™
Compliant Leads Contact Set

Top or device side

Back or load board side

Electronic Handling & Protection Division

3M Innovation
MicroTouch™
Compliant Leads Contact Set

• Piercing contact
  – Oxide penetration
  – No wipe
  – Multiple contact points

• Long life
  – Hard particles
  – Easy to clean
MicroTouch™
Compliant Leads
Elastomeric Nest

Slab style rubber
for TQFP

Full rubber fins
for QFP, CQFP
MicroTouch™
Area Grid Arrays
Operation
Design Evaluation
MicroTouch™
Compliant Leads
Mechanical Specifications

Temperature range  -55° to +165° C
Contactor life       > 1,000,000 insertions
Lead press life     > 200,000 insertions
Insertion force     10 – 20 grams/lead
Cleaning interval    Dependent on environment
MicroTouch™
Area Grid Arrays
Mechanical Specifications

- Temperature range: -55° to +165° C
- Contactor life: > 1,000,000 insertions
- Elastomer element life: > 200,000 insertions
- Insertion force: 12 grams/lead
- Cleaning interval: Dependent on environment
MicroTouch™
Area Grid Arrays
Electrical Specifications

Self inductance: 0.32 nH (interior lead)  Mutual inductance: 0.06 nH
0.36 nH (corner lead)  Mutual capacitance: 0.016 pF

Frequency response: Linear 50 MHz to 10.05 GHz
MicroTouch™
Area Grid Arrays
Features and Benefits

• Wide Bandwidth for high frequency testing (10 GHz)

• Low inductance/capacitance preserves signal integrity
  – Total contact length of only 1mm
  – Lead inductance < 0.36 nH
  – Contact Resistance < 0.05Ω

• Advanced mechanical design minimizes ball damage
  – Very low contact force
  – Ball guided for precise alignment

• Long operating life provides low cost of ownership