Burn-in & Test Socket Workshop 2000

Session 6

New Technologies

IEEE COMPUTER SOCIETY

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BURN-IN & TEST
SOCKET WORKSHOP

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Presentations

“Using MicroSpring^{tm} Contacts As Second Level Interconnect”

John Novitsky
FormFactor

“A New Burn-in Socket For Fine Pitch BGAs”

Yuji Wada, Hitachi Ltd.
Akio Hasebe, Hitachi Ltd.
Kenichiro Morinaga, Hitachi Ltd.

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

Tomoaki Soshi
Enplas Corporation

“Novel Contacting Technology For Fine Pitch Leaded & Area Array Devices”

Frank Bumb, 3M
Ron Revell, 3M

Using MicroSpring™ Contacts as Second Level Interconnect

BiTS Workshop
Mesa, Az.
28 February 00

John Novitsky
VP Business Development
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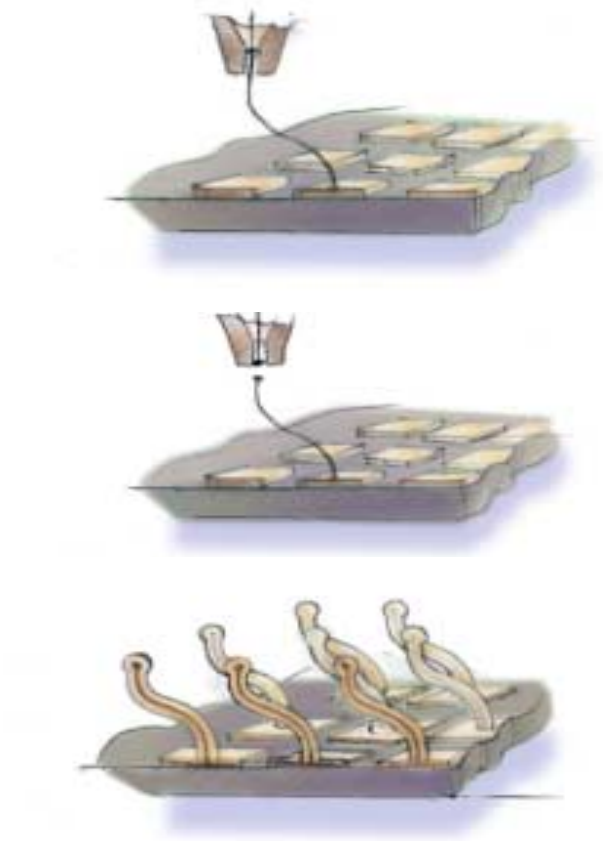
Primary Invention: MicroSpring™ Contact



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

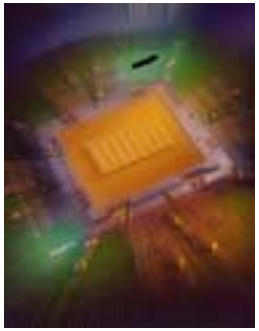
2. Patented wire cut process for z axis planarity.

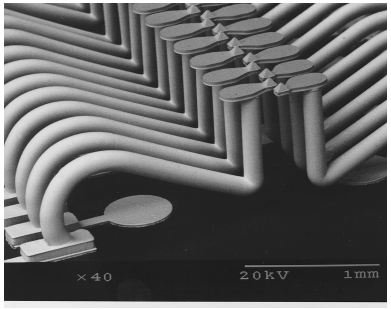
3. Overcoat the “Skeleton” with a spring alloy to form a MicroSpring Contact.

Two Business Models

Product

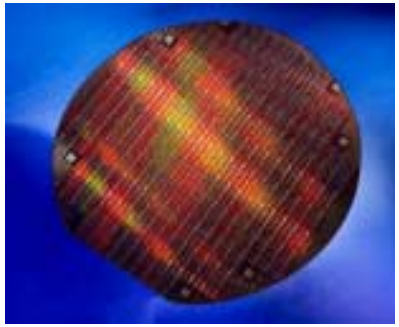
Probe Cards

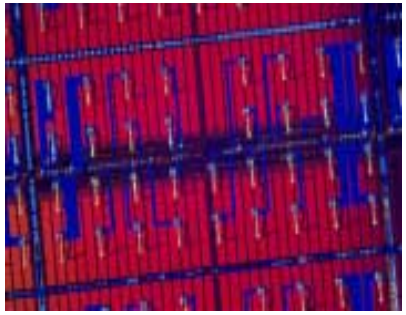




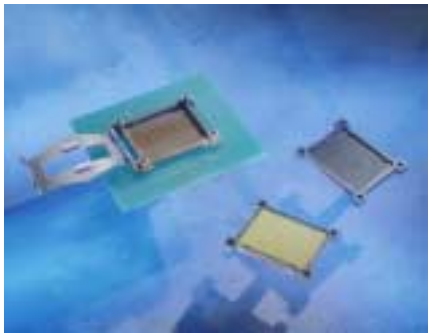
IP Licensing

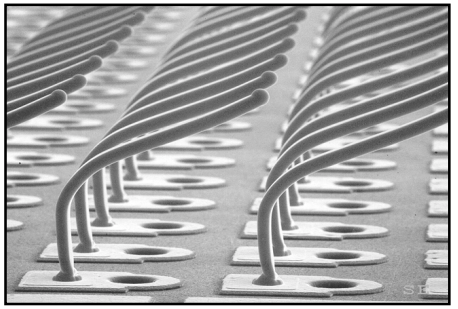
WOW/MOST



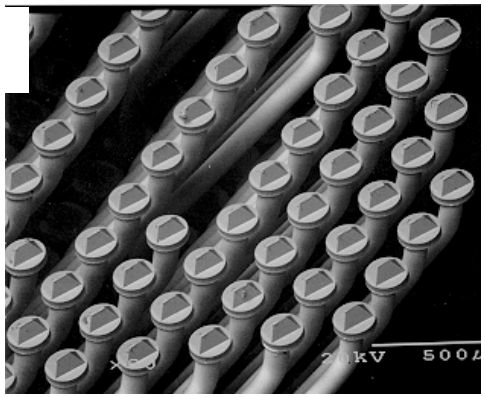


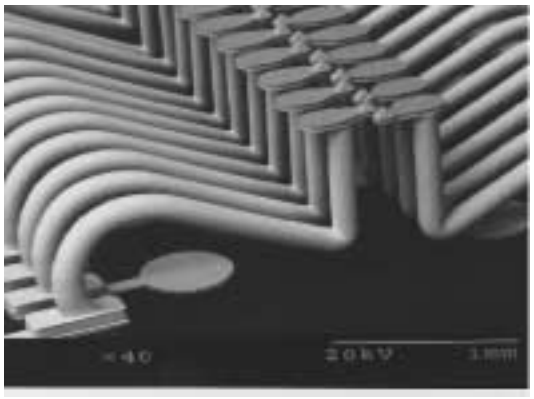
Sockets





Probe Card: for C4 Balls or Al Pads





MicroSpring™ probe elements:

MicroSpring contactors on C-4 probe card

Space Transformer with Microspring™ probes

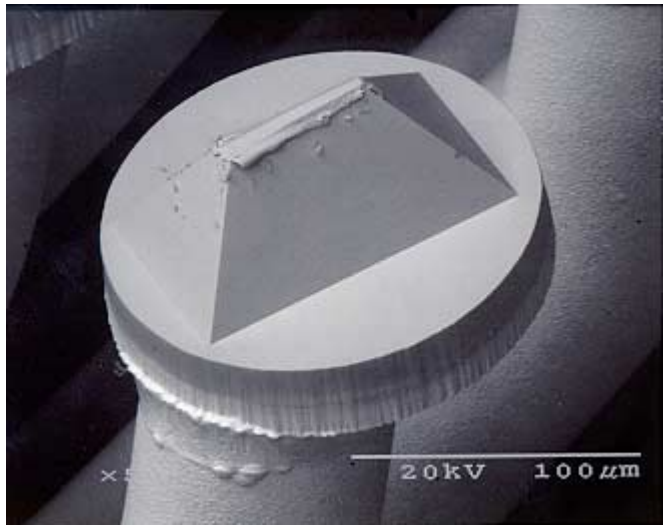
MicroSpring contactors on x32 Memory Probecard

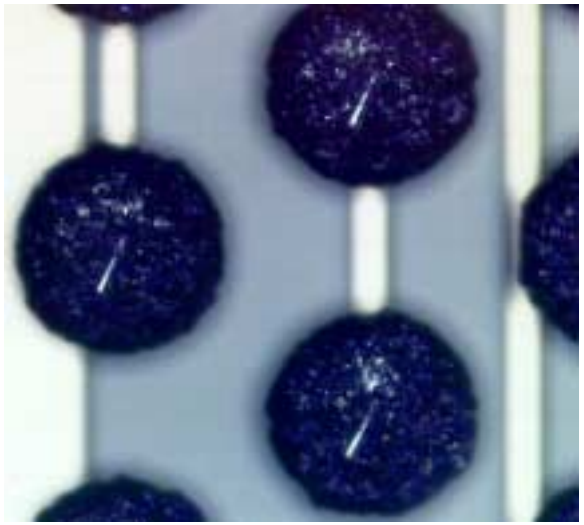
Resilient Microspring ***Interposer:***

3-pt Planarizer

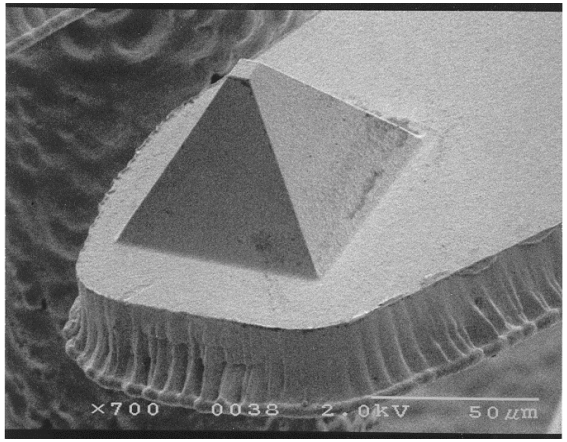
Controlled Impedance tester interface ***PCB Assembly***

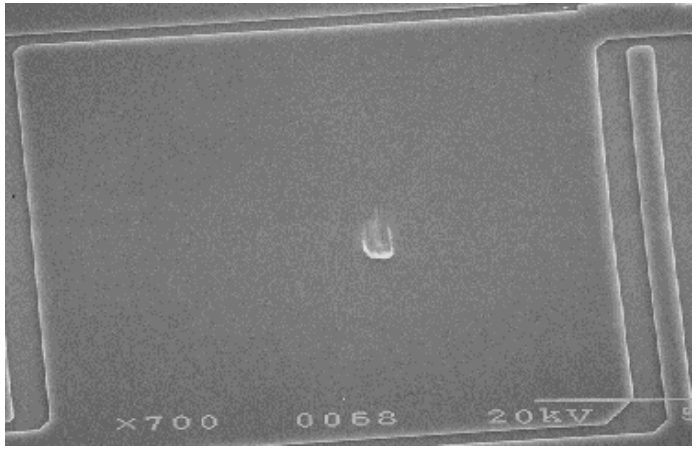
C4 Probe Cards





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.

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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

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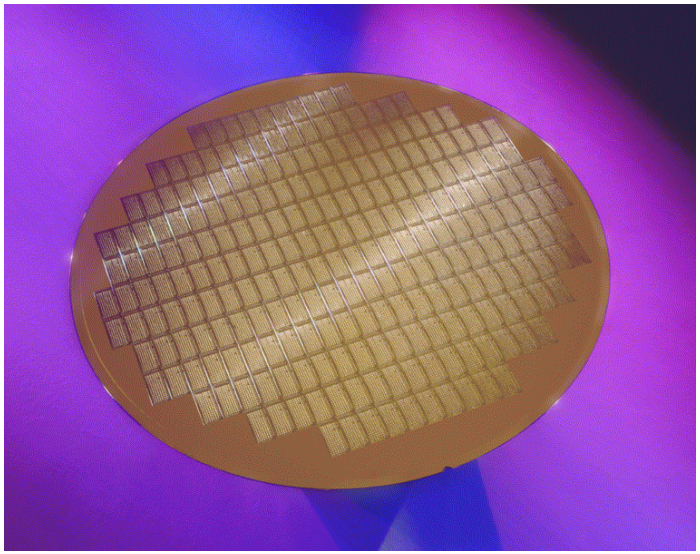
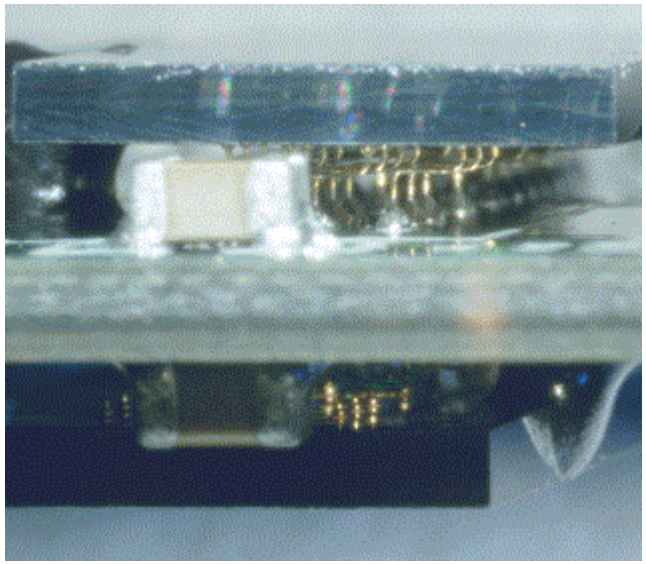
MicroSpring Contacts on Silicon

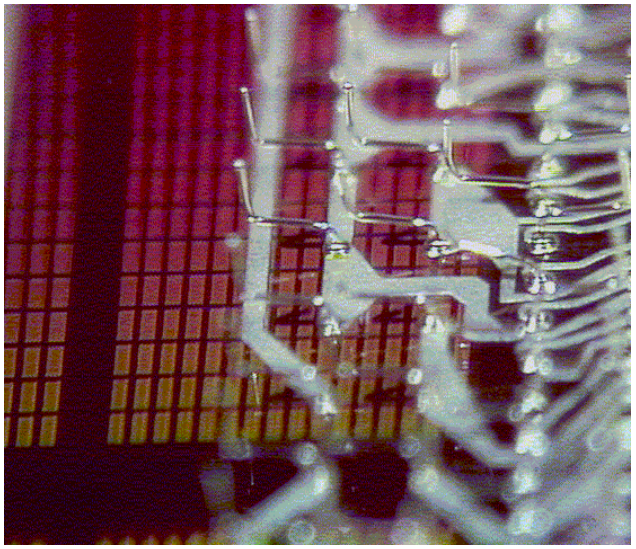


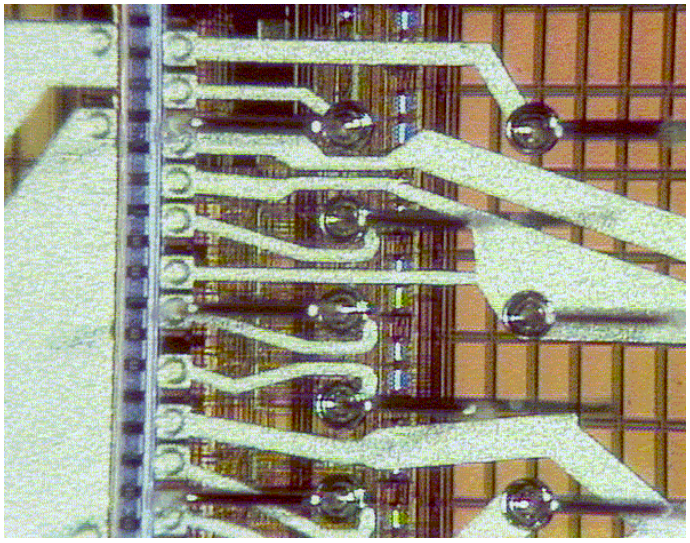
Wafer Covered with
MicroSpring Contacts



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.

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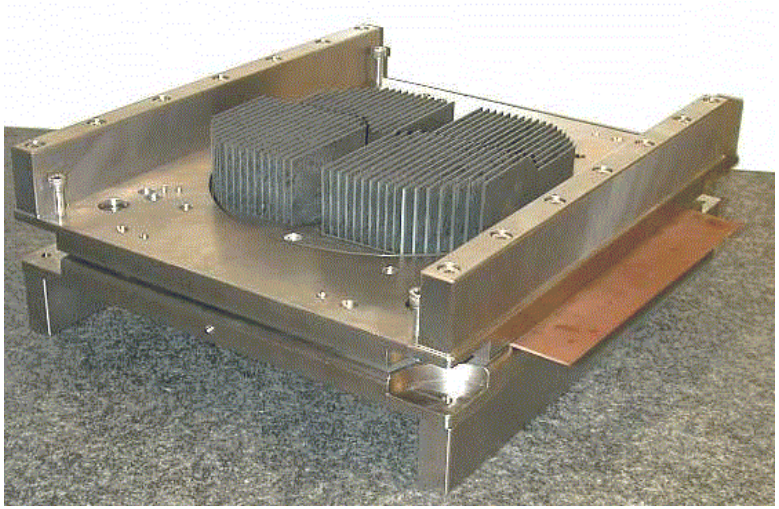
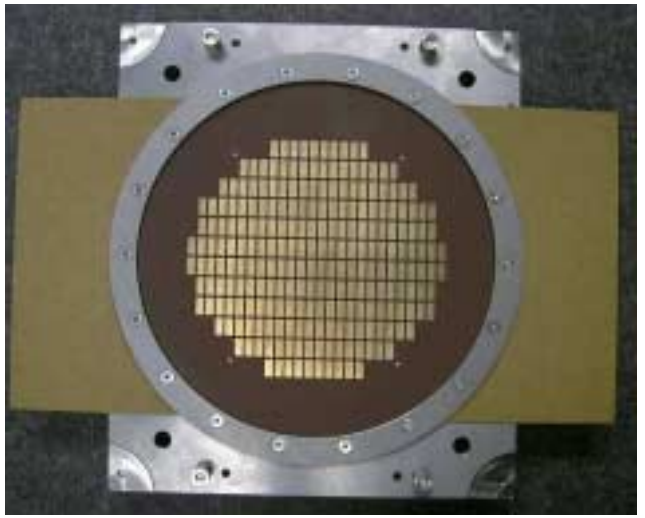
MOST WLBI Clamp and Contactor





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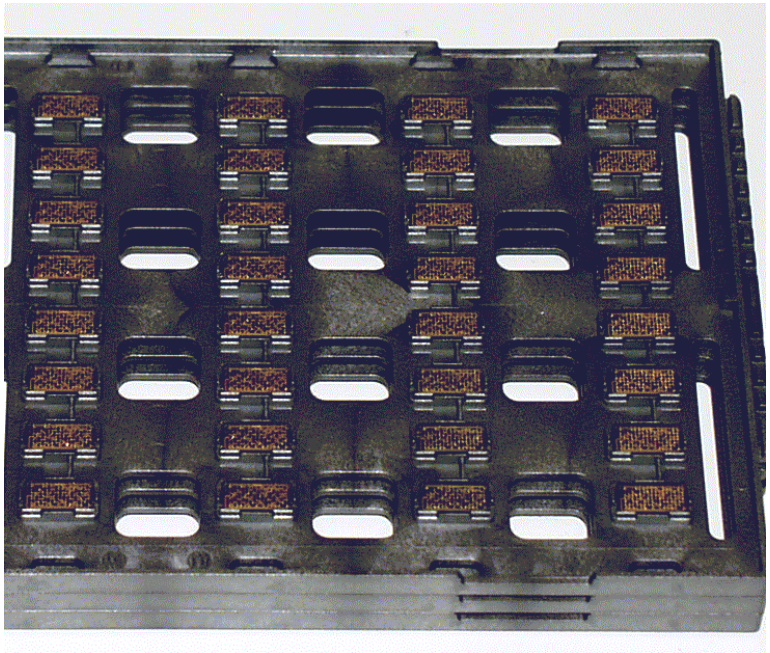
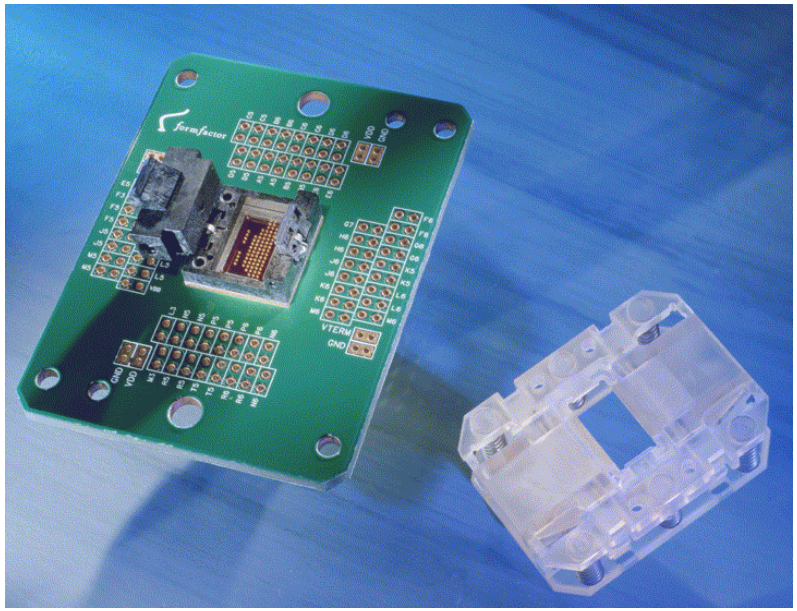
MOST Sockets





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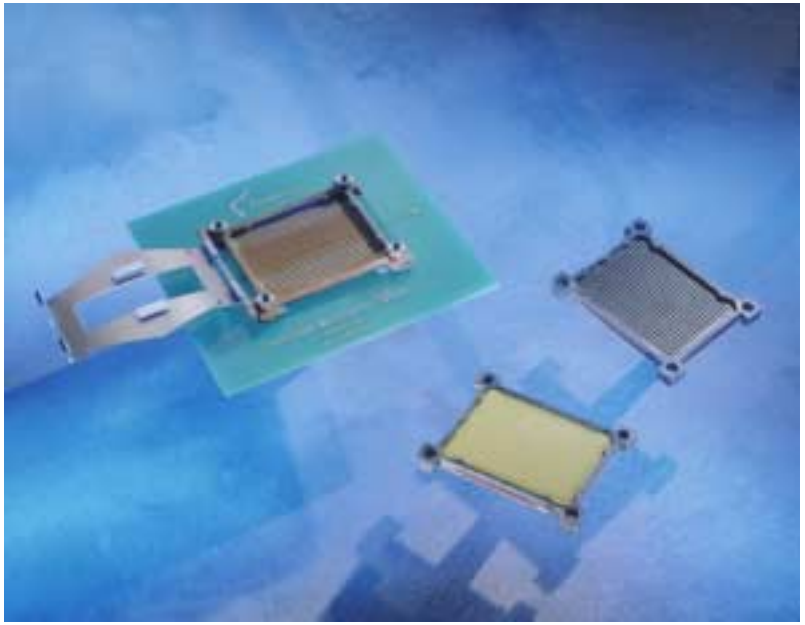
MicroSpring Contacts in Burn-in

- 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.

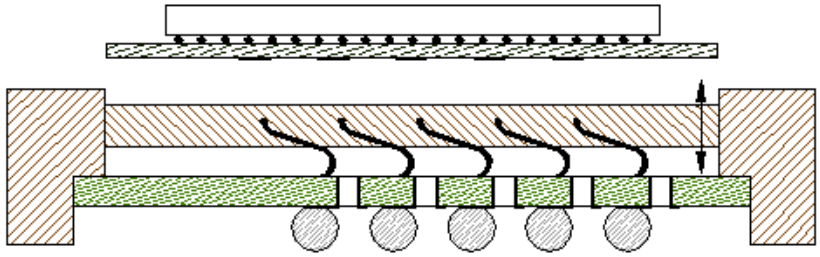
FFI Socket Strategy

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



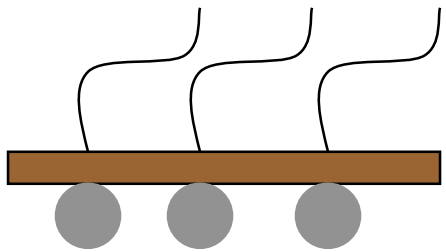
	LGA	BGA
Production Sockets	x	
Bring-up Sockets	x	x

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



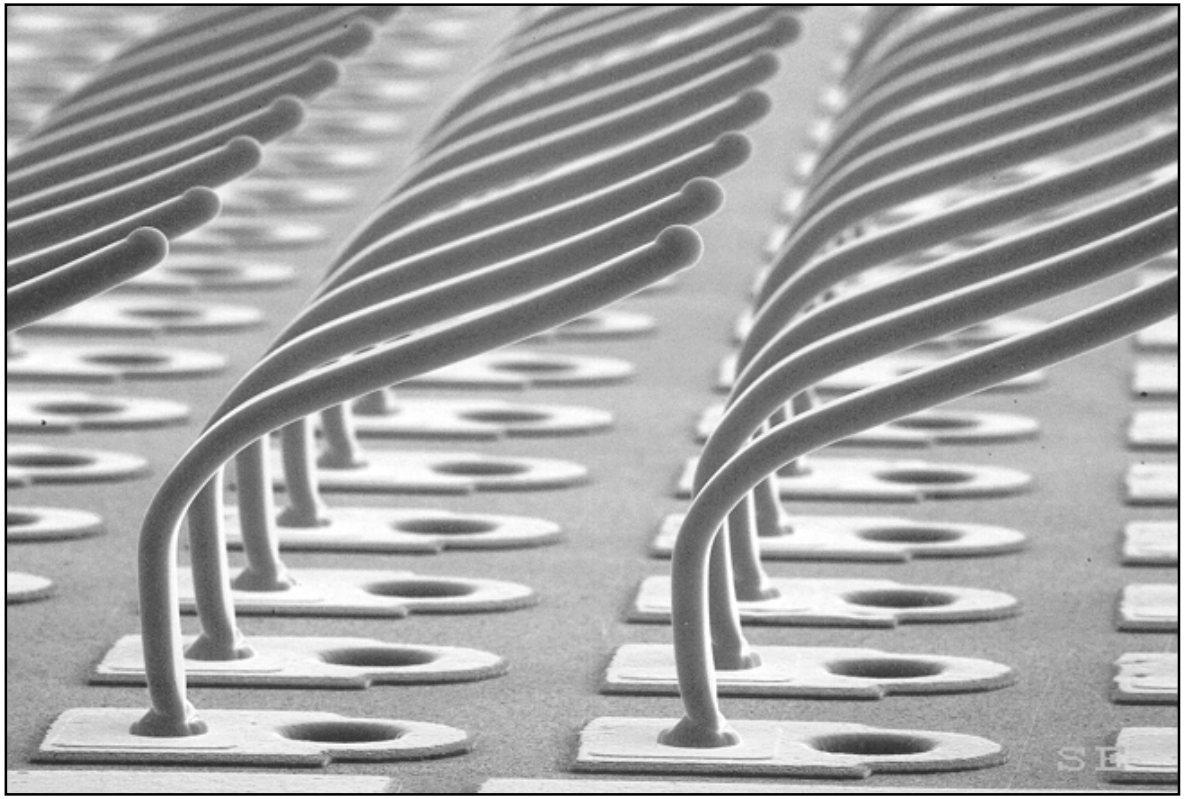
Contactor: 35 Mils (compressed)

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



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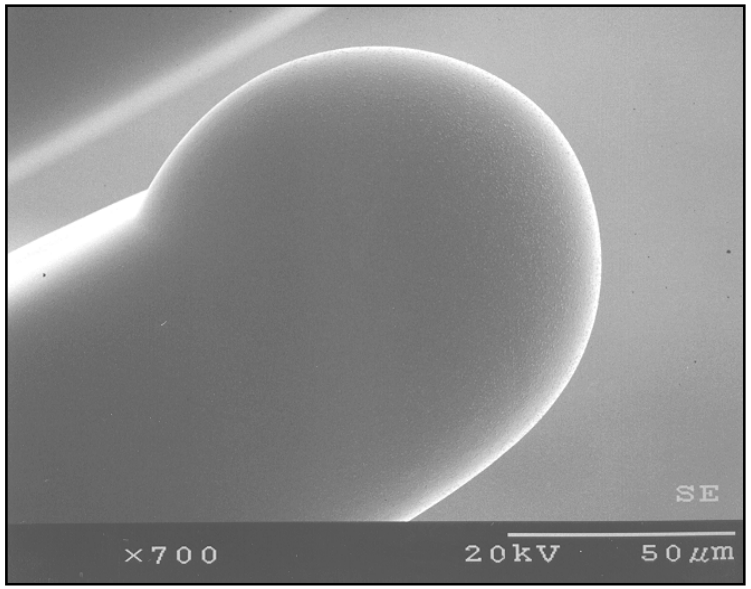
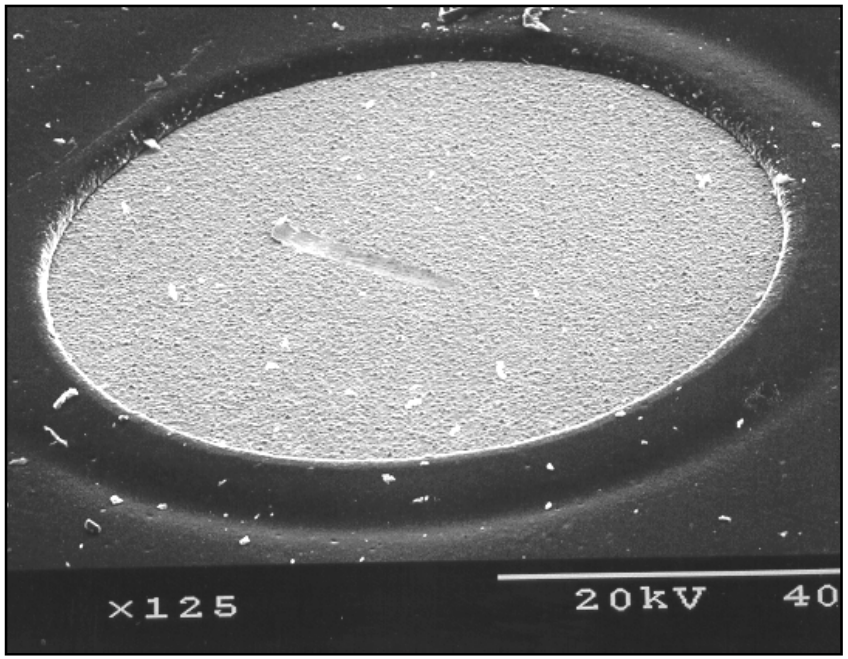
Wiping Au Tip on Au Pad

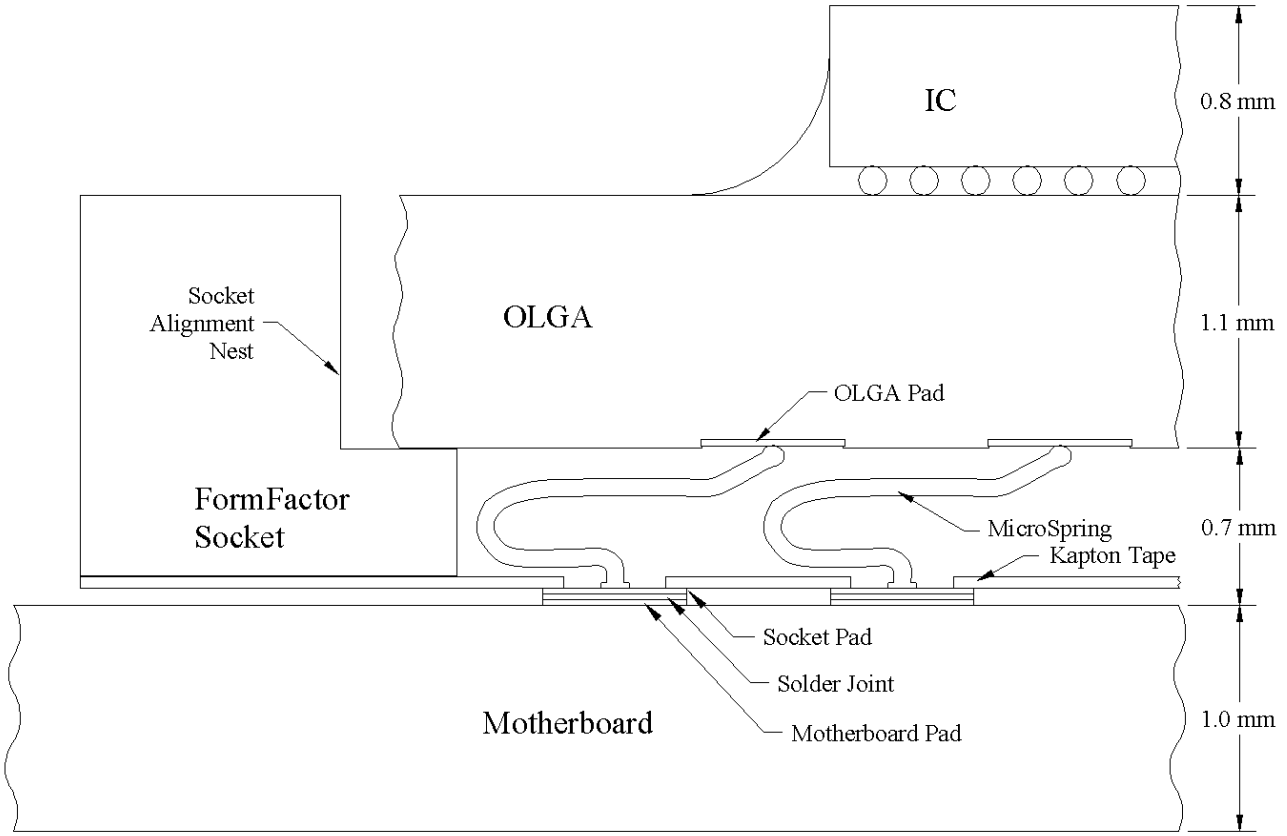


Au Spherical Tip

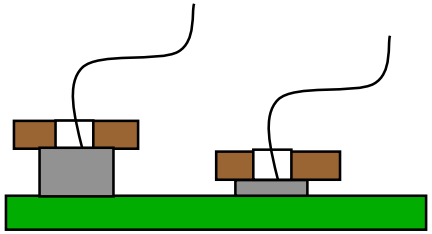


Scrub Mark on Au Pad

Example 2: 0.7 mm Socket Stackup



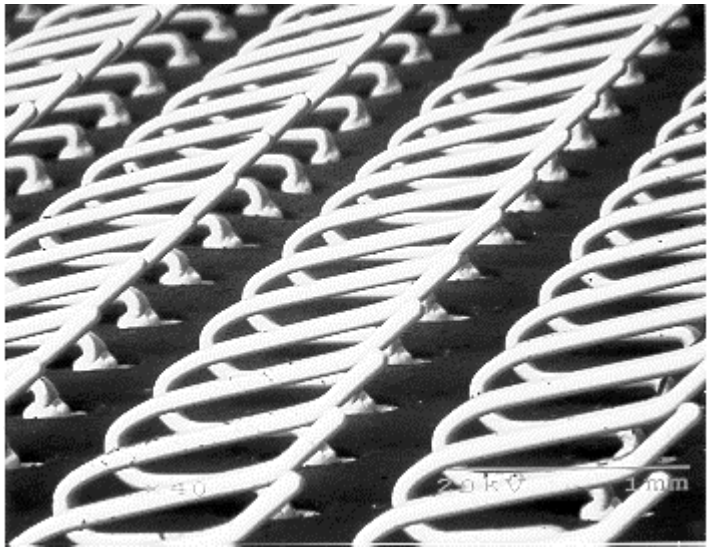
0.7mm Socket Stackup

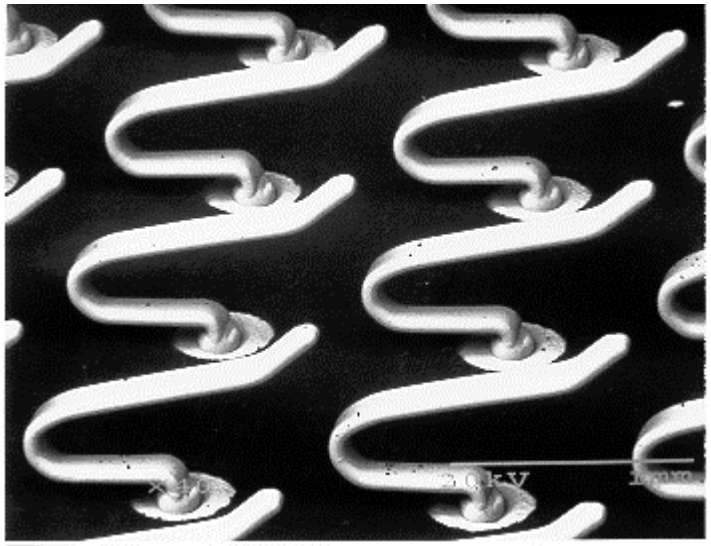


	Before Attach	After Soldering
Contact:	33 Mils	21 (compressed)
Substrate:	3 Mils	3 Mils
Solder:	6 Mils (stencil print)	1 Mil
Pad:	1 Mil	1 Mil
Total:	43 Mils	26 Mils (0.7mm)

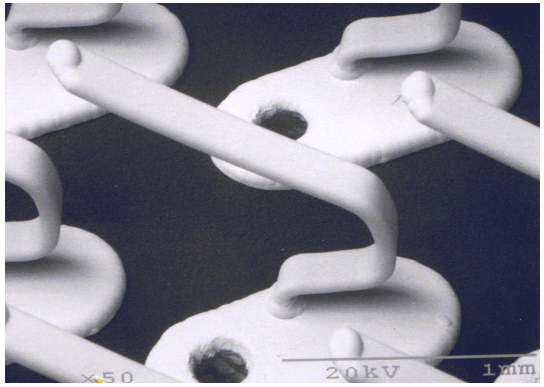
Scrub:	~ 6 Mils (measured)
Compliance:	~ 12 Mils (measured)
Series Resistance:	~ 9 mOhms (measured)
Inductance:	~0.62nH (simulated)

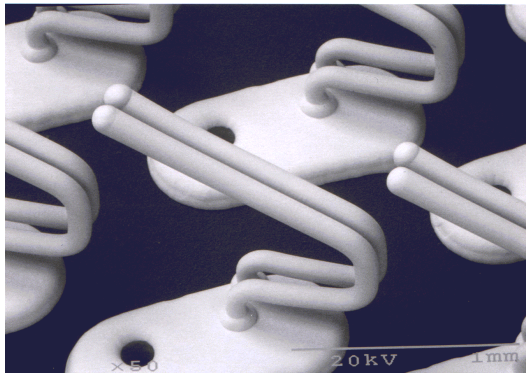
0.7mm MicroSpring Contacts

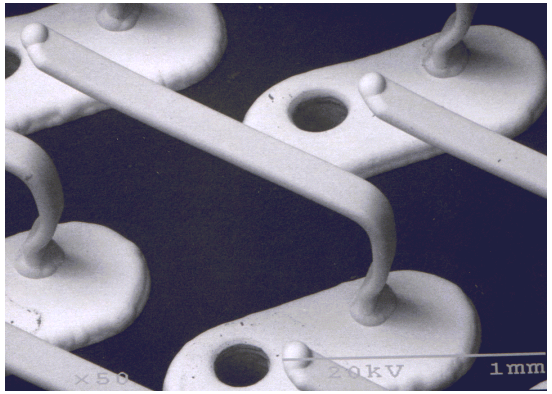


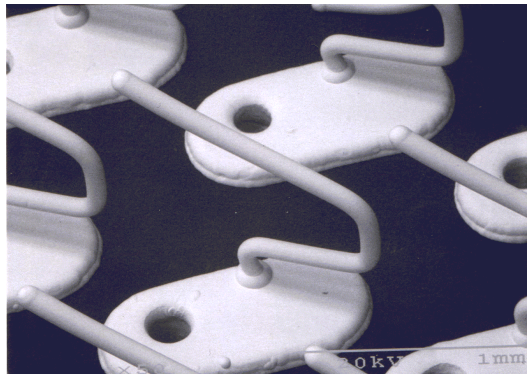


Additional Contact Shapes

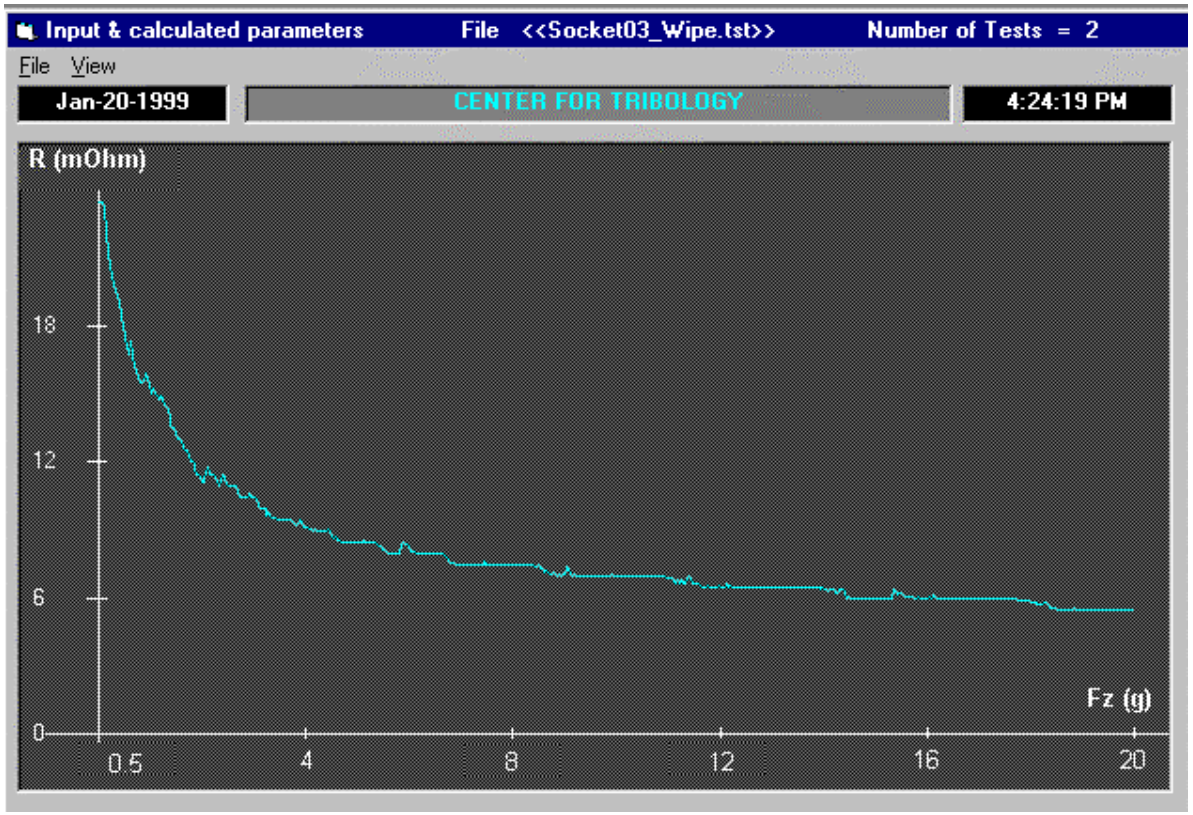




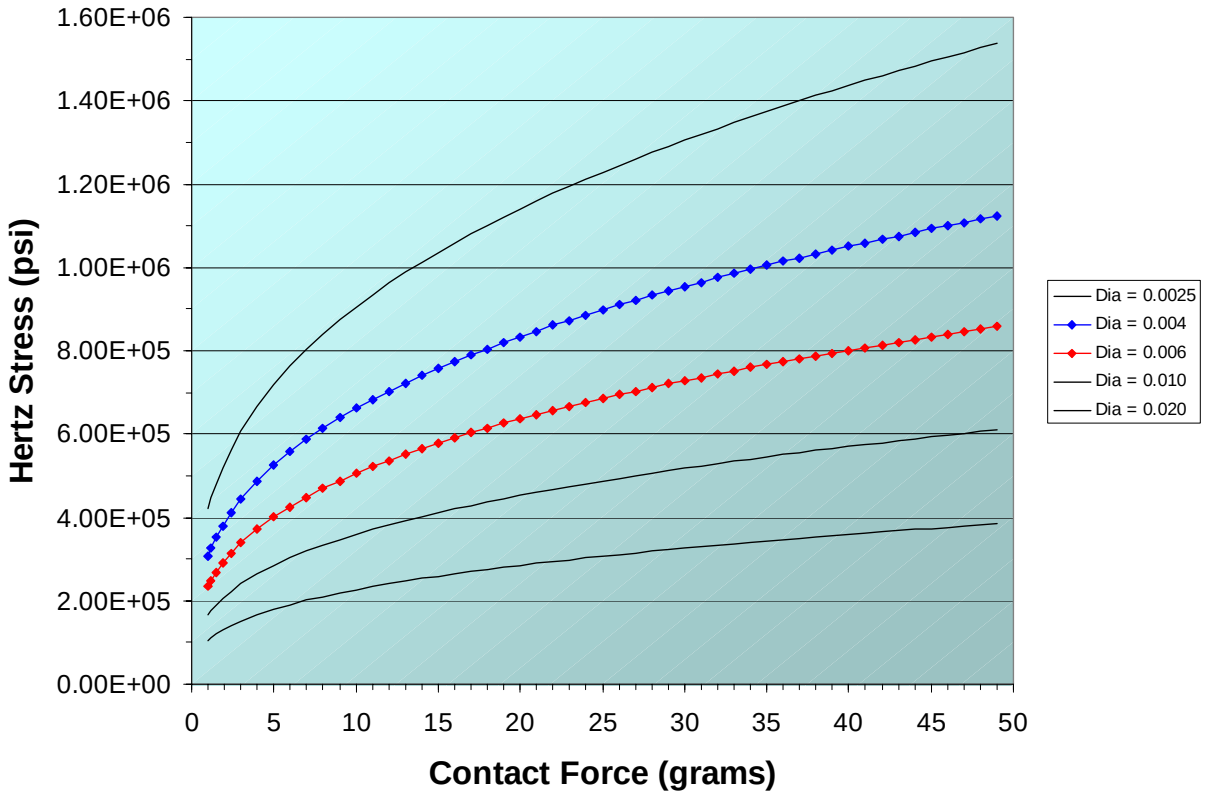


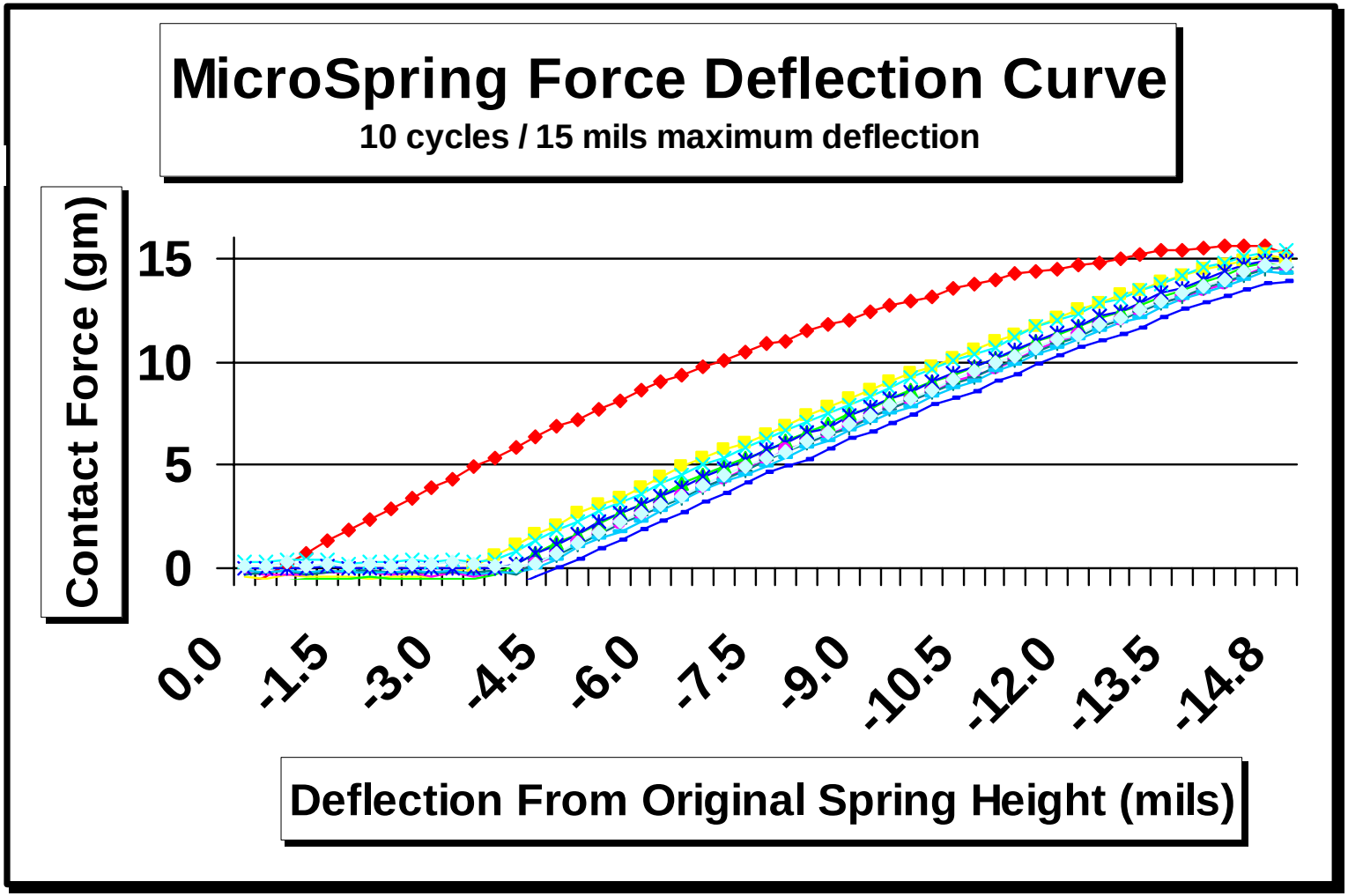


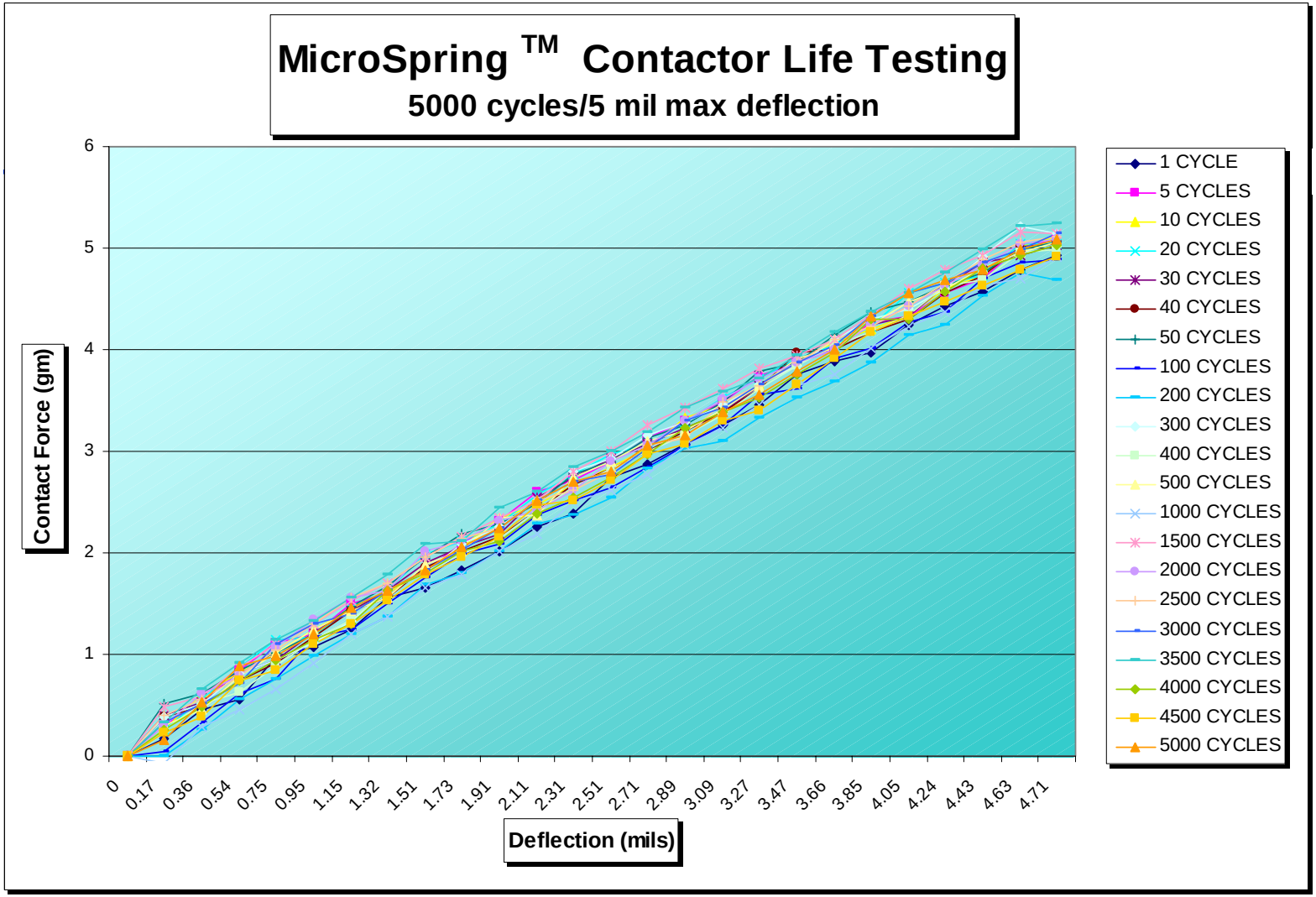
CRES “Knee of the Curve” ~5 Grams



MicroSpring Contactor Hertzian Stress Exceeds Minimums for Reliable Lifetime Contact




MicroSpring Force Deflection Curve
10 cycles / 15 mils maximum deflection
Contact Force (gm)
15
10
5
0
0.0
-1.5
-3.0
-4.5
-6.0
-7.5
-9.0
-10.5
-12.0
-13.5
-14.8
Deflection From Original Spring Height (mils)


MicroSpring ™ Contactor Life Testing
5000 cycles/5 mil max deflection
Contact Force (gm)
0
1
2
3
4
5
6
0
0.17
0.36
0.54
0.75
0.95
1.15
1.32
1.51
1.73
1.91
2.11
2.31
2.51
2.71
2.89
3.09
3.27
3.47
3.66
3.85
4.05
4.24
4.43
4.63
4.71
Deflection (mils)
1 CYCLE
5 CYCLES
10 CYCLES
20 CYCLES
30 CYCLES
40 CYCLES
50 CYCLES
100 CYCLES
200 CYCLES
300 CYCLES
400 CYCLES
500 CYCLES
1000 CYCLES
1500 CYCLES
2000 CYCLES
2500 CYCLES
3000 CYCLES
3500 CYCLES
4000 CYCLES
4500 CYCLES
5000 CYCLES

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***:
  - Mechanical: Initial Mating Force, Resistance, Durability, Vibration, Mech Shock, Resistance
  - 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

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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

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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

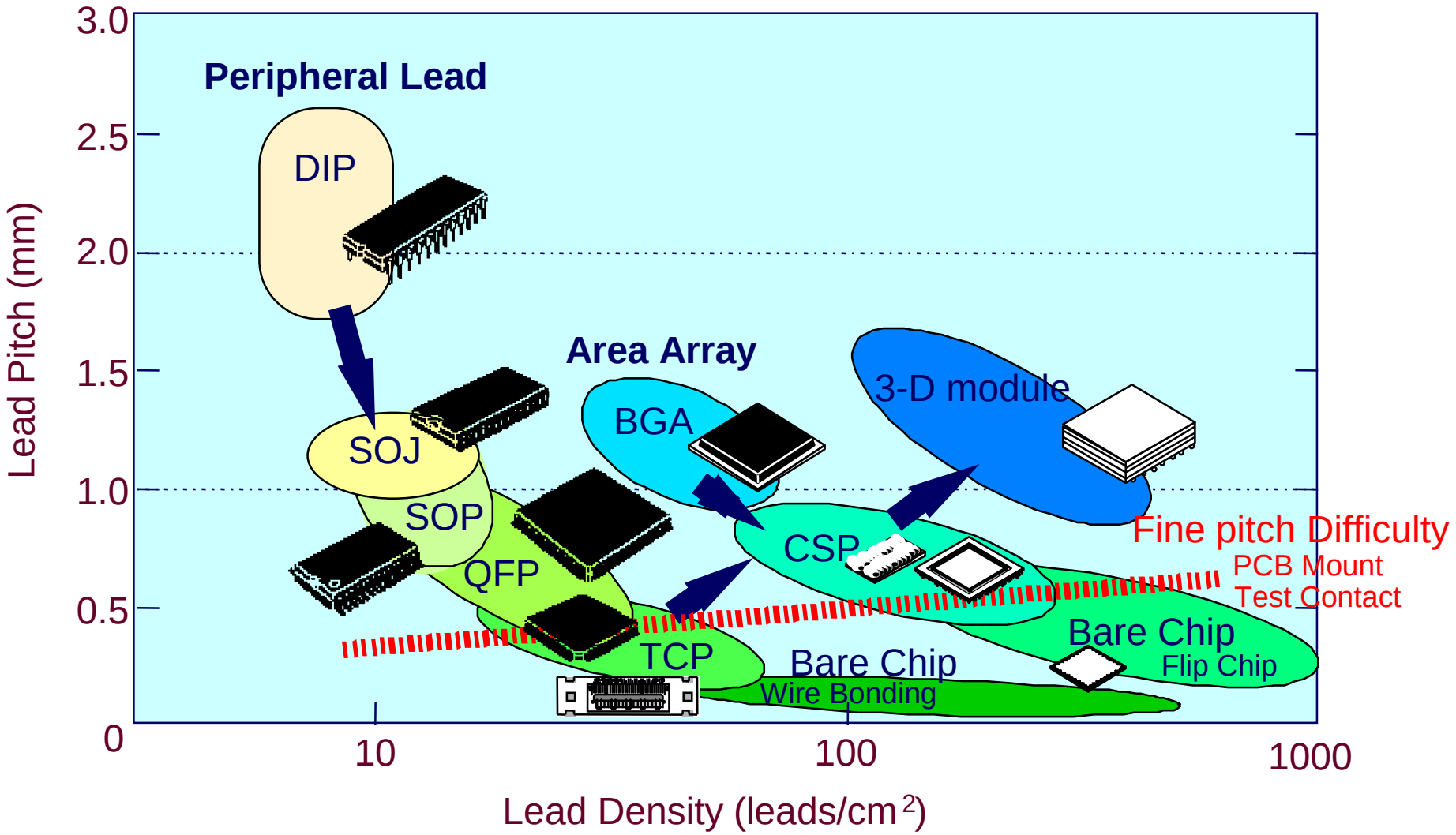
Hiroyuki Mogi , Hokuto Kanesashi Tomoaki Soshi

Semiconductor Peripherals Div.,Enplas Corporation

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

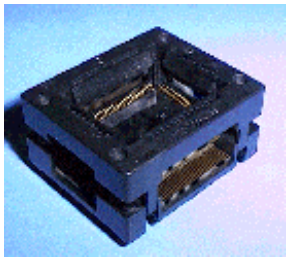
Market Trend



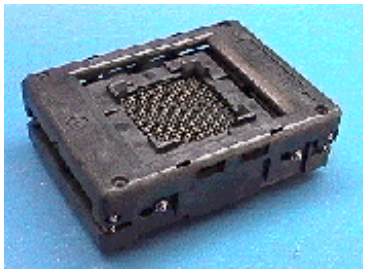
Market Trend

LOGIC SOCKET

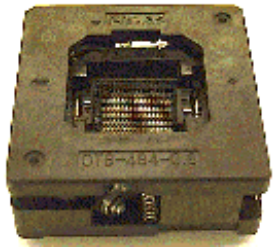
QFP



BGA

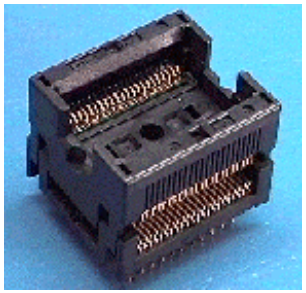


CSP-0.8

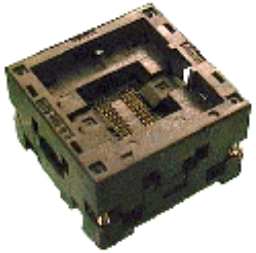


MEMORY SOCKET

TSOP



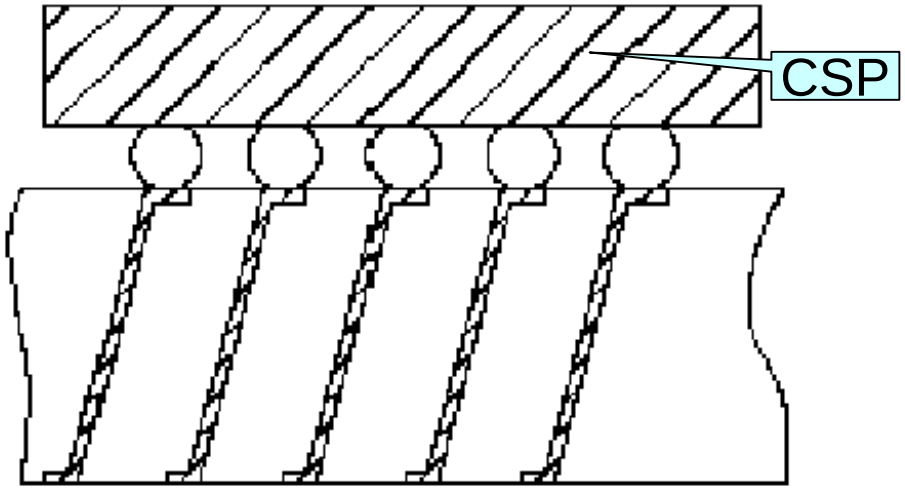
CSP-0.8/-0.75



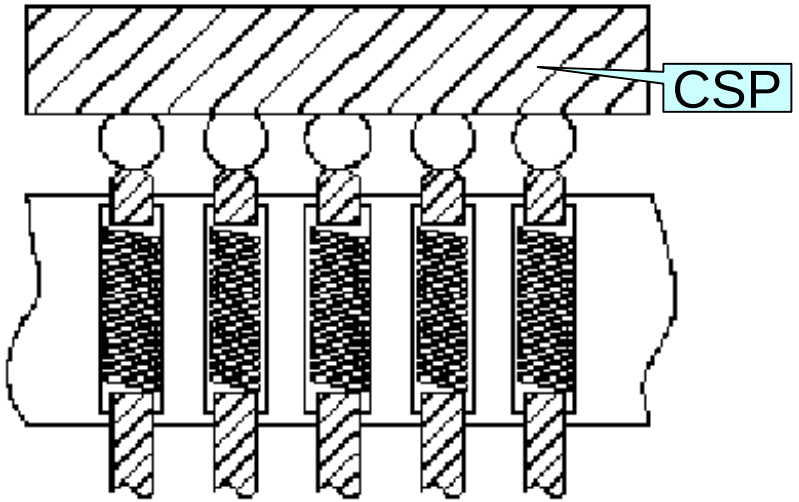
CSP-0.5mm pitch SOCKET

Market Trend

Current Socket Design for CSP 0.5 mm Pitch



Sheet Rubber Type



Spring Probe Pin Type

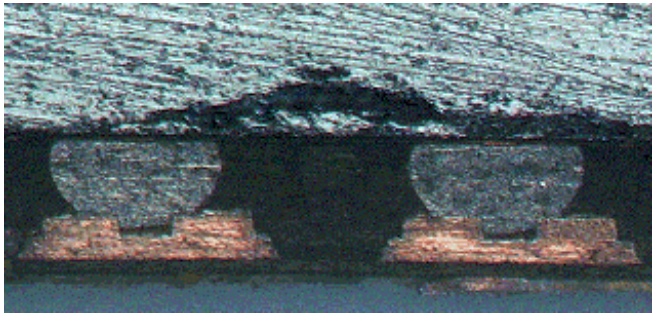
Technical Issue and Its Countermeasure
Technical Issues

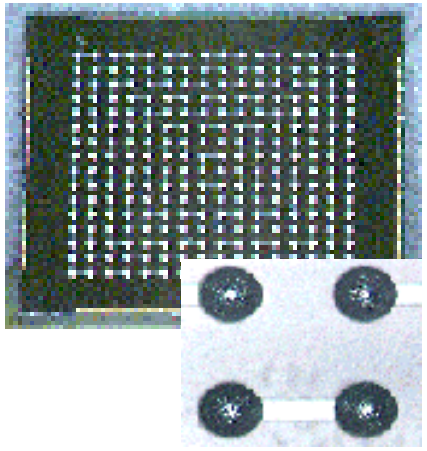
- Reliable & economical contact for less than 0.5 mm pitch is not yet established.
  - Longer Life Cycle after Burn-in (125 deg. C.)
  - Less Solder Ball Deformation after Burn-in (125 deg. C.)
  - Absorption for Uneven Solder Ball Height
  - Accurate Precise Alignment of Socket Assembly
- Difficulty of BIB Design Followed by Package Fine Pitch Tendency

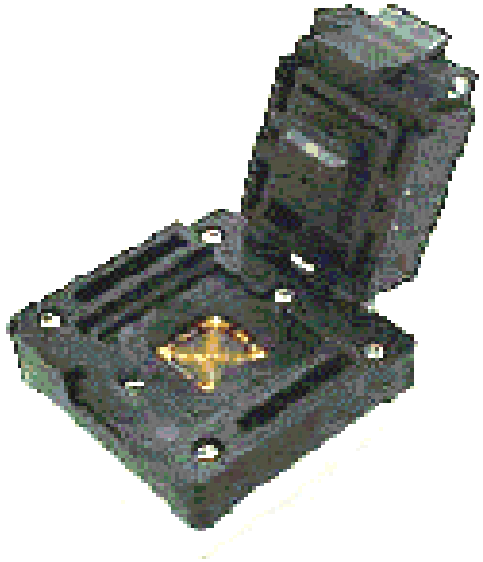
Technical Issue and Its Countermeasure
Countermeasures

- 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

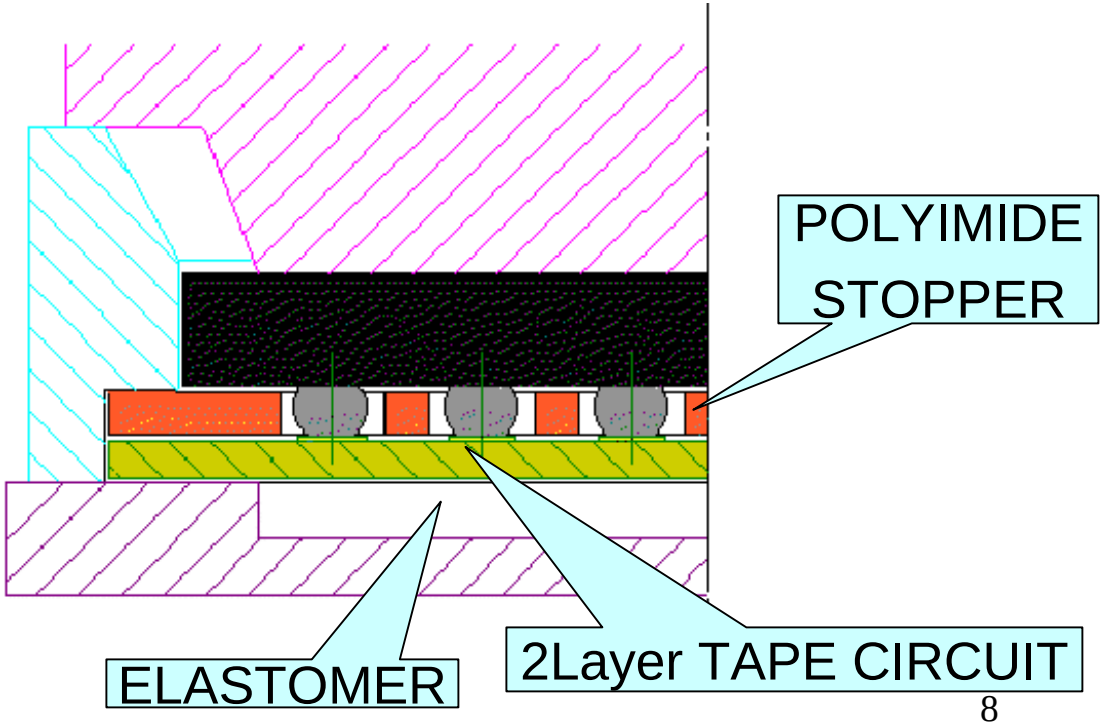
- **2 Layered Wiring**
- **Polyimide Stopper**
- **Elastomer**







Sheet Contact SOCKET

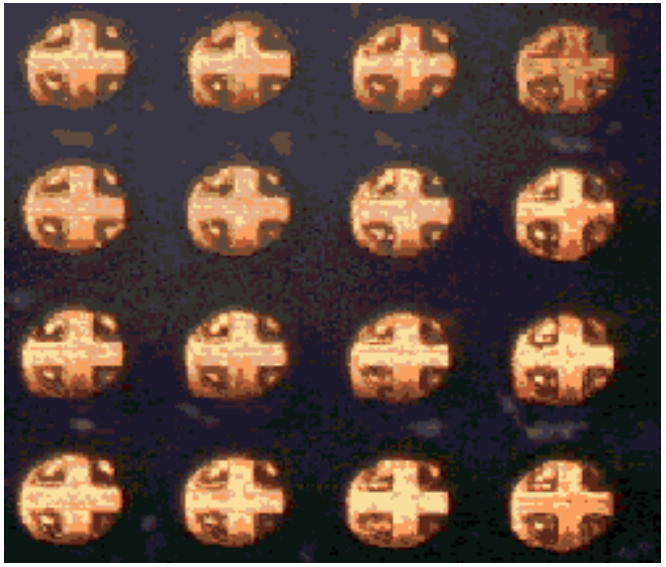


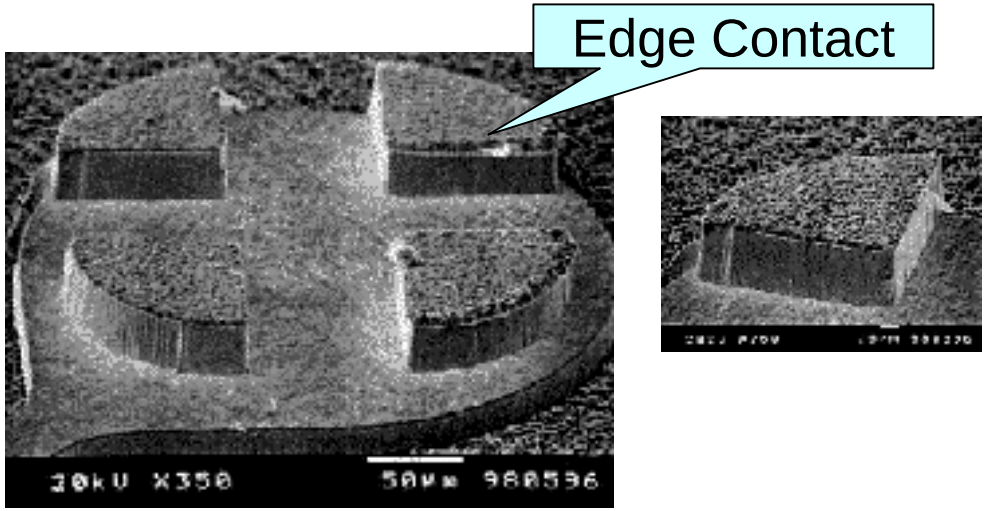
Socket Technology

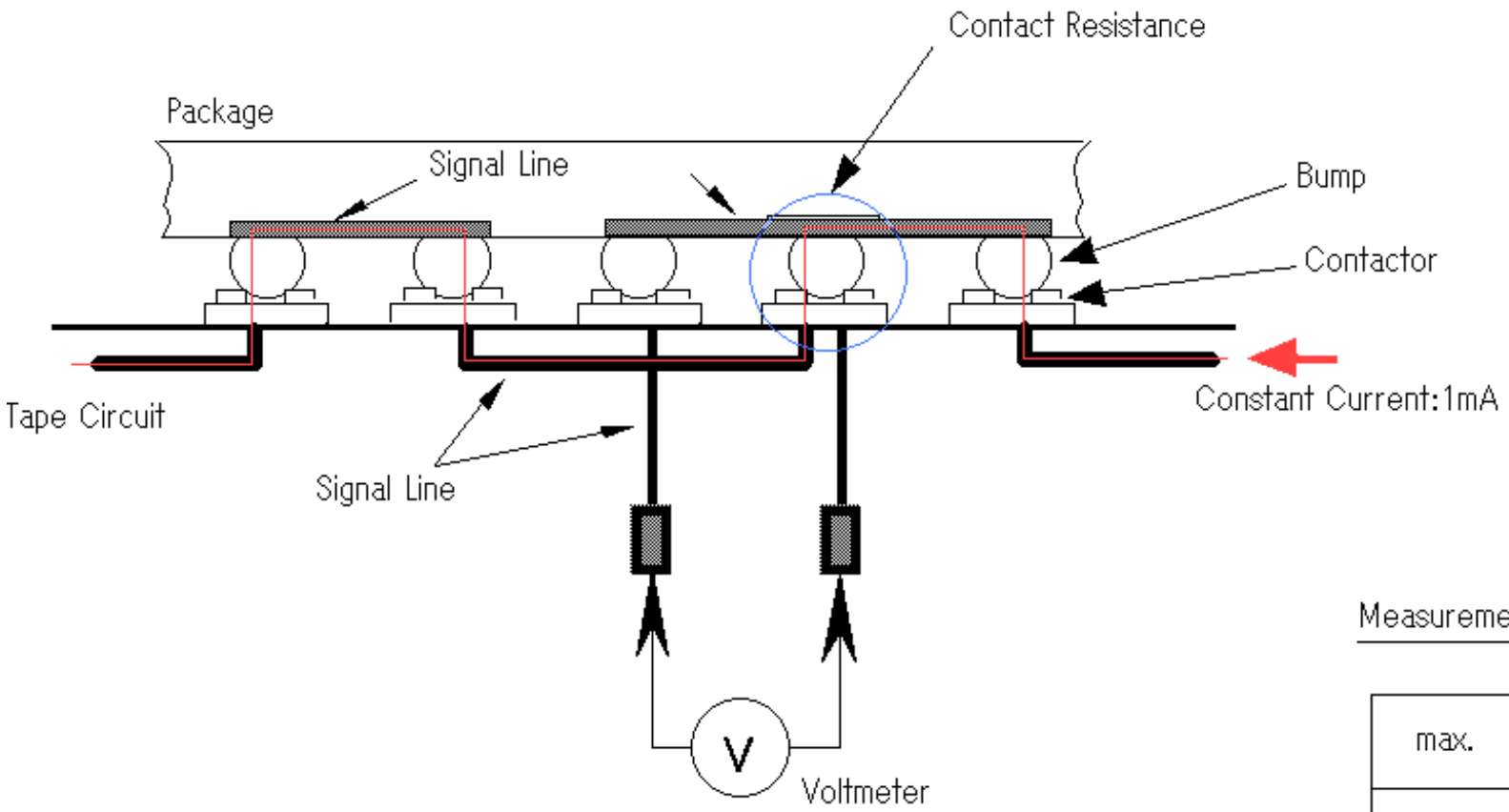
- Projection Formed Contact Technology
- Reduction of Solder Ball Deformation
- Absorption for Uneven Solder Ball Height
- Accurate Alignment on Socket Assembly
- Tape Circuit Fanned-out

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







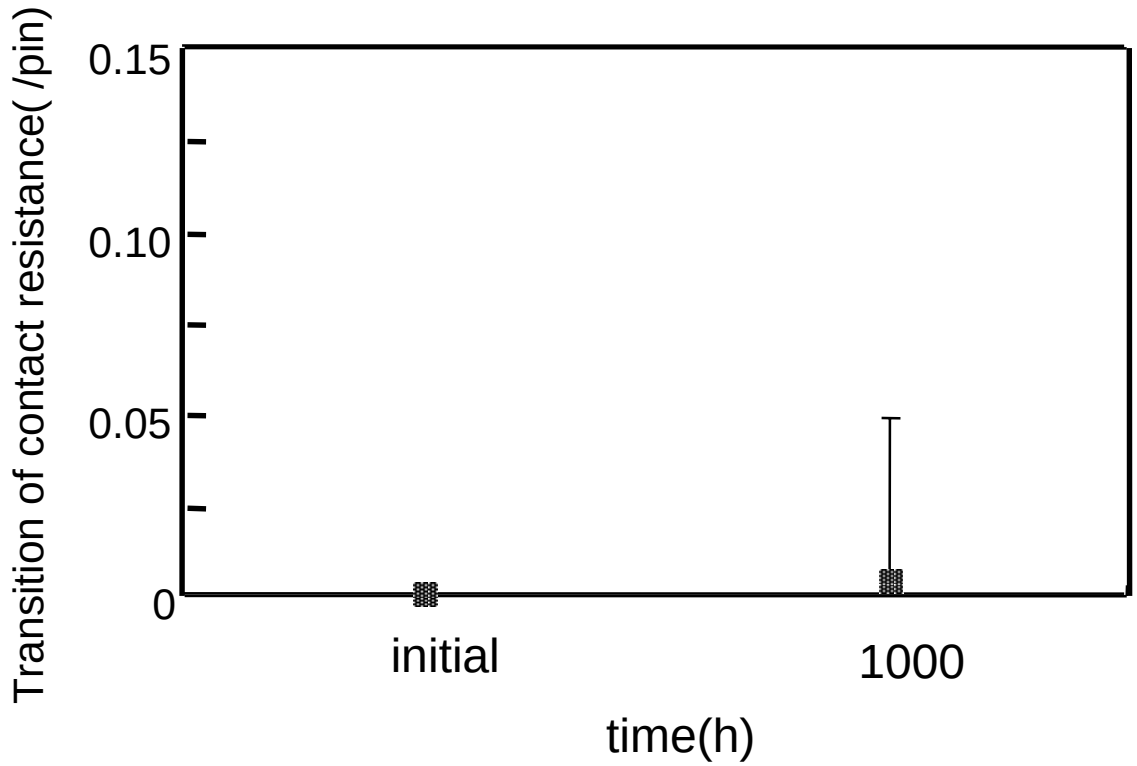
Measurement data

unit : m Ω

max.	8.5
Ave.	5.44
min.	2.6

Principle of 4 probe method

Socket Technology
Engineering Data



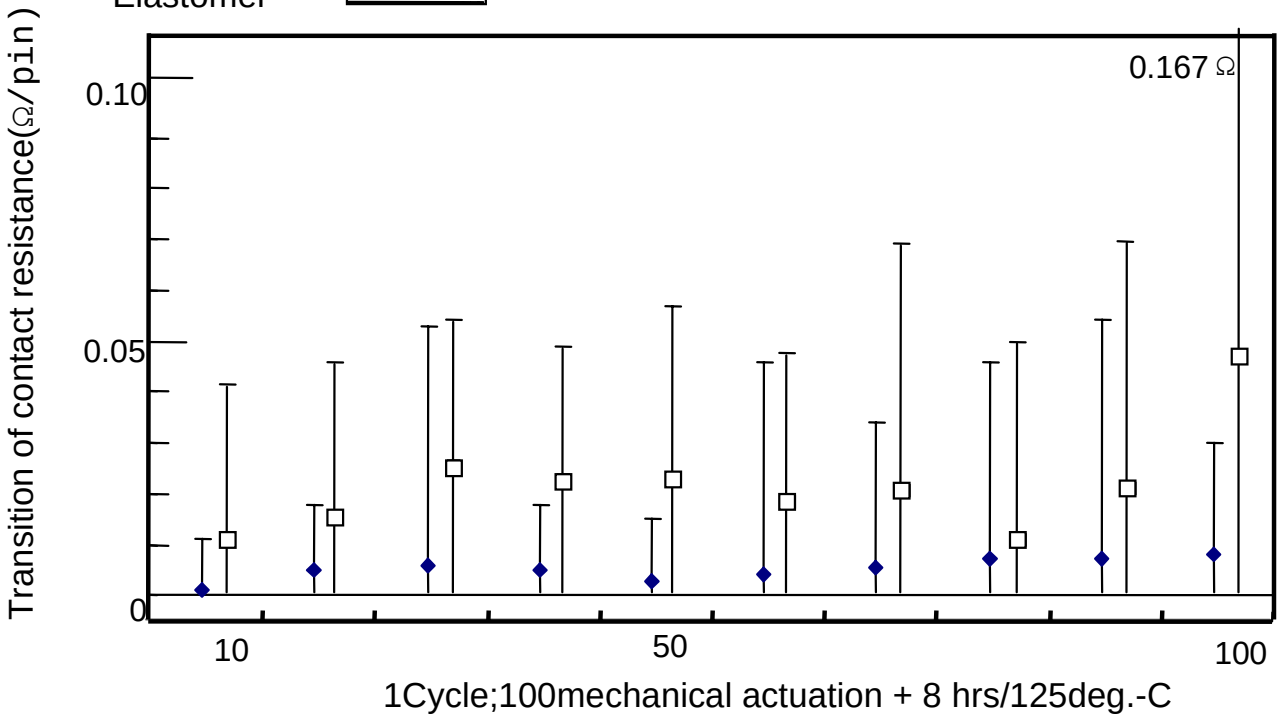
Transition of Contact Resistance
after 125deg.-C for 1000hours

New Socket Technology
Engineering Data

ackage

◆ Developed Socket
Solder 64Sn-36Pb
Structure
S older ball
F
Package
Contactor
Elastomer

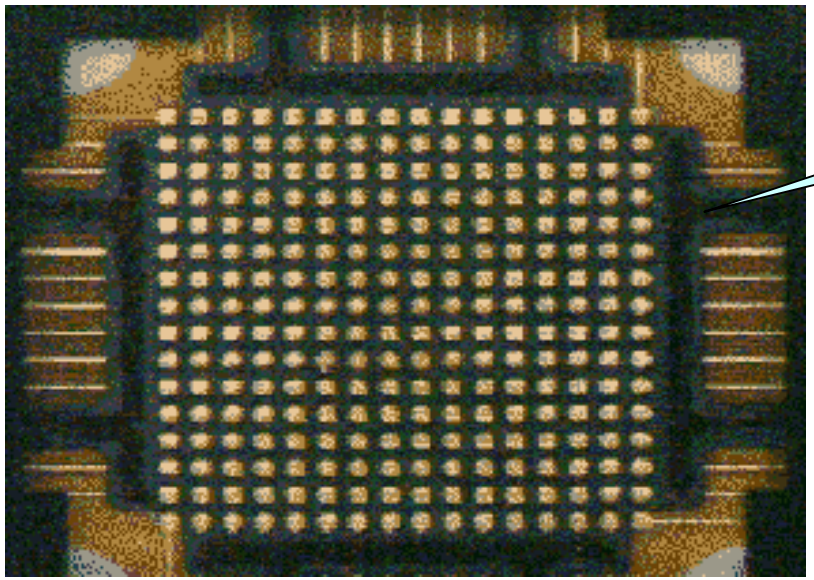
□ Socket for 0.8mm pitch/48pin BGA
S older Sn-Ag-Cu
S tructure
P ackage
S older ball
F
F
C ontactor



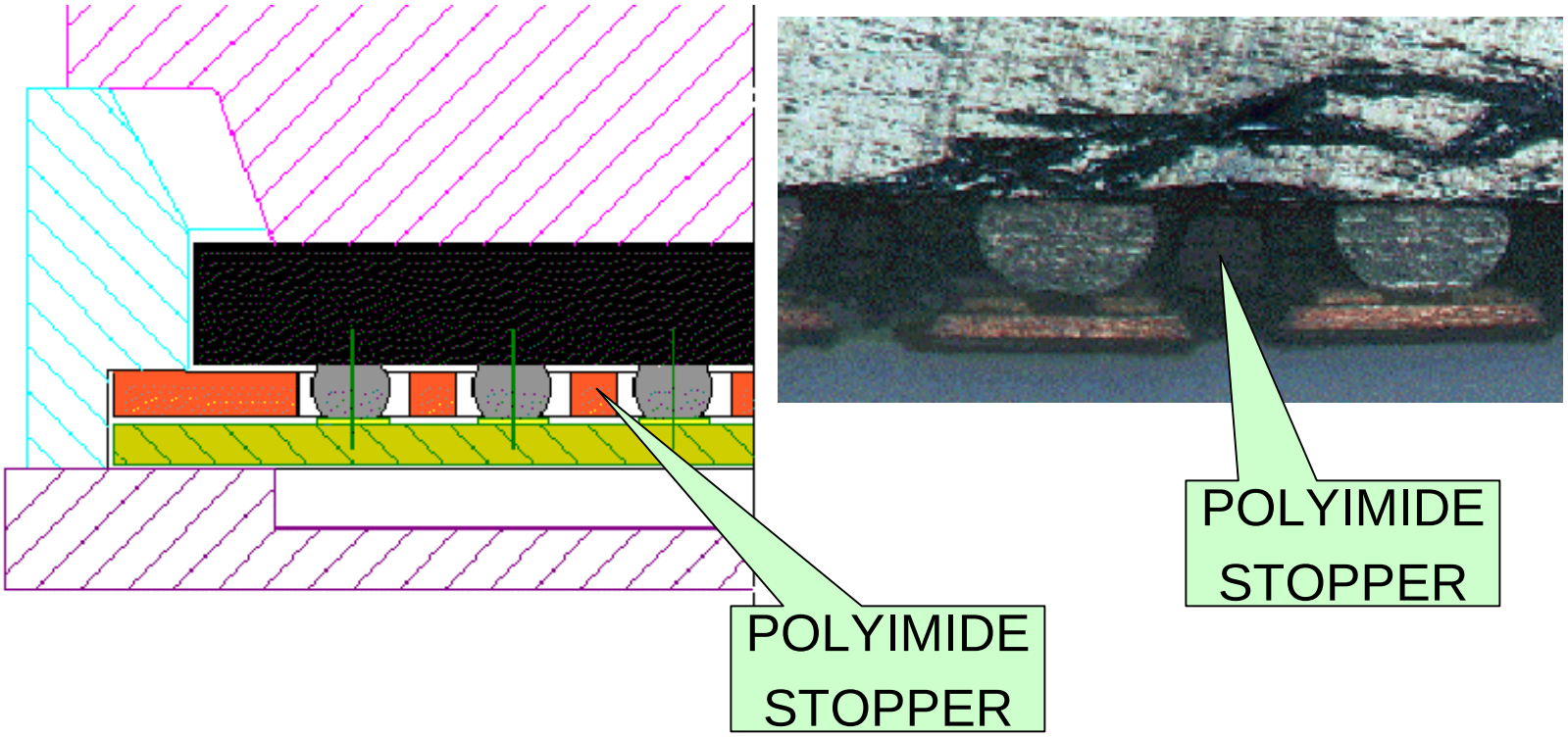
Result of Evaluation for Contact life time

Socket Technology
Reduction of Solder Ball Deformation

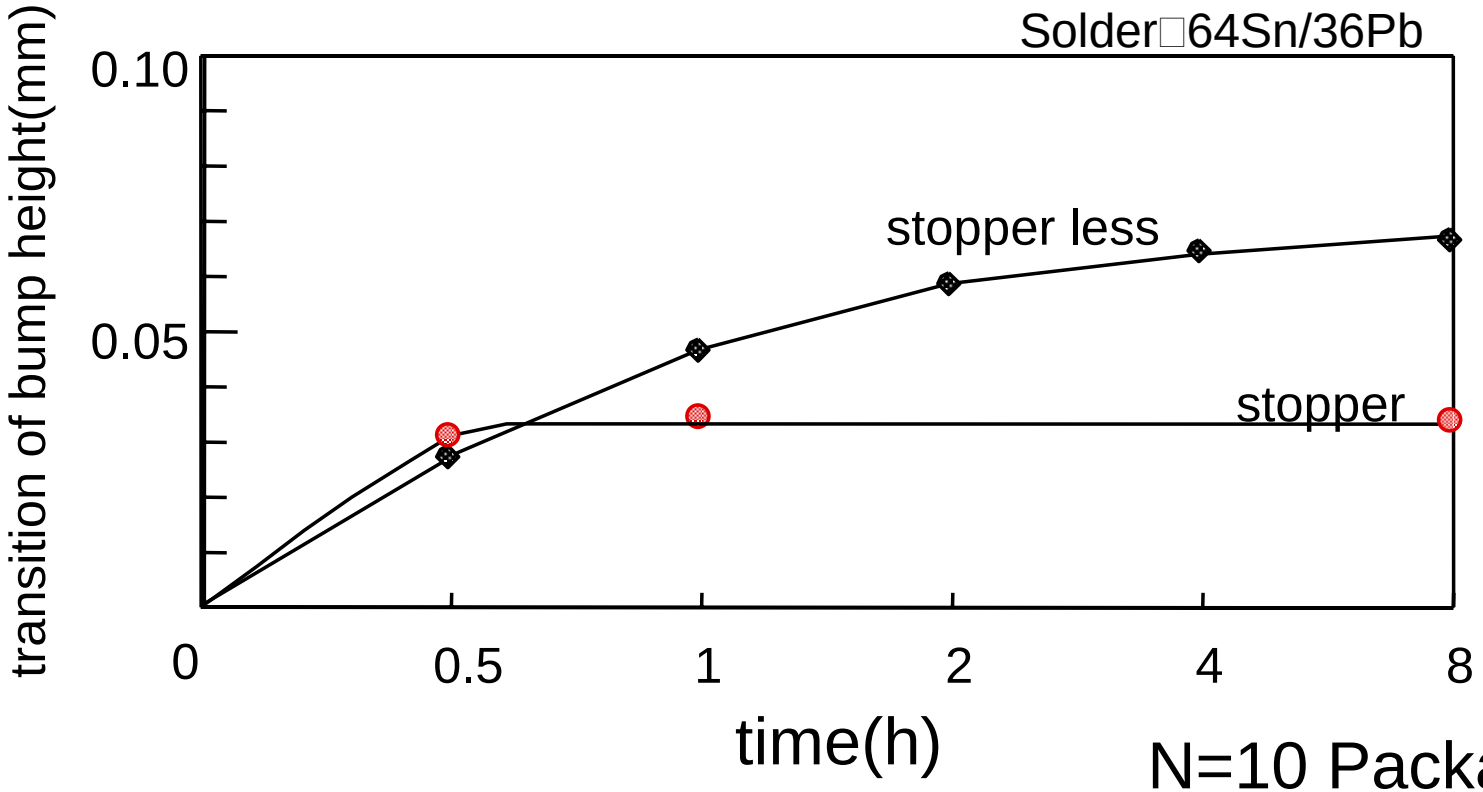
- By using polyimide stopper, even Sn/Pb solder ball can be minimized. Pb free solder ball can be more minimized.



Socket Technology
Reduction of Solder Ball Deformation

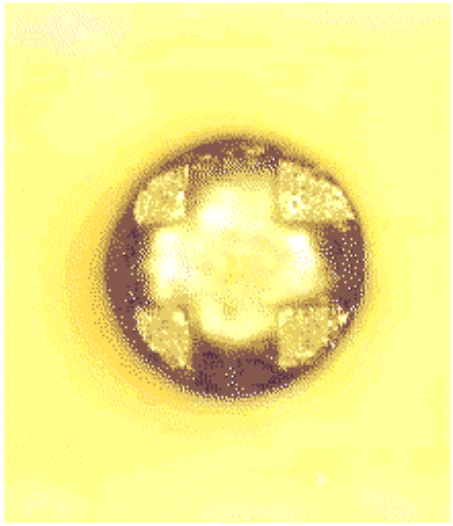
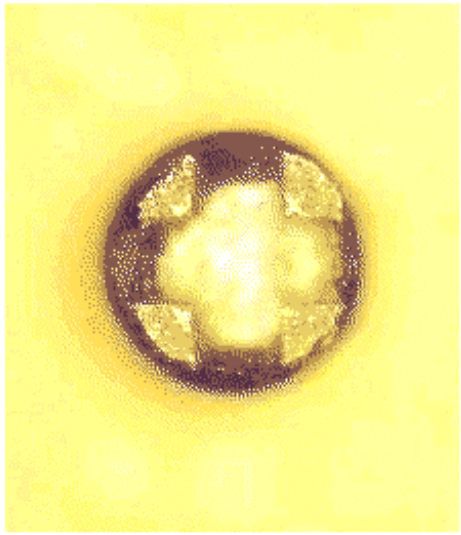


Transition of bump height Data (w/ and w/o Polyimide Stopper

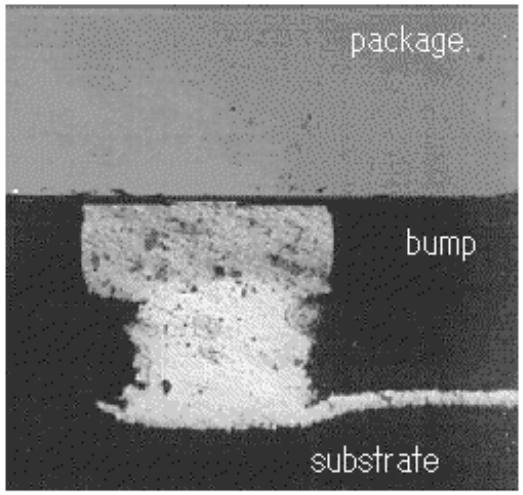
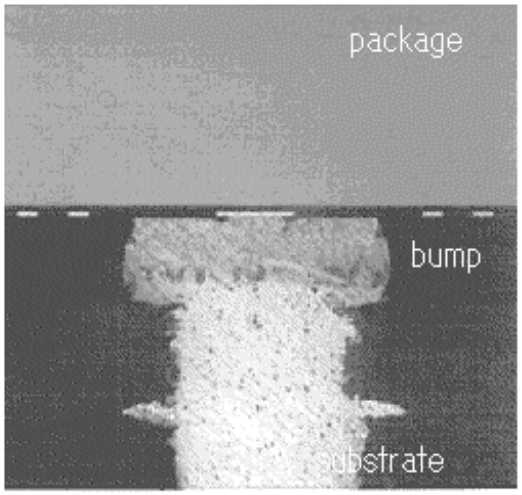


Transition of bump height at 150deg.-C

solder : 64Sn/36Pb

stopper less	stopper	
150deg.-C for 1h	150deg.-C for 1h	150deg.-C for 8h
 0.1mm		

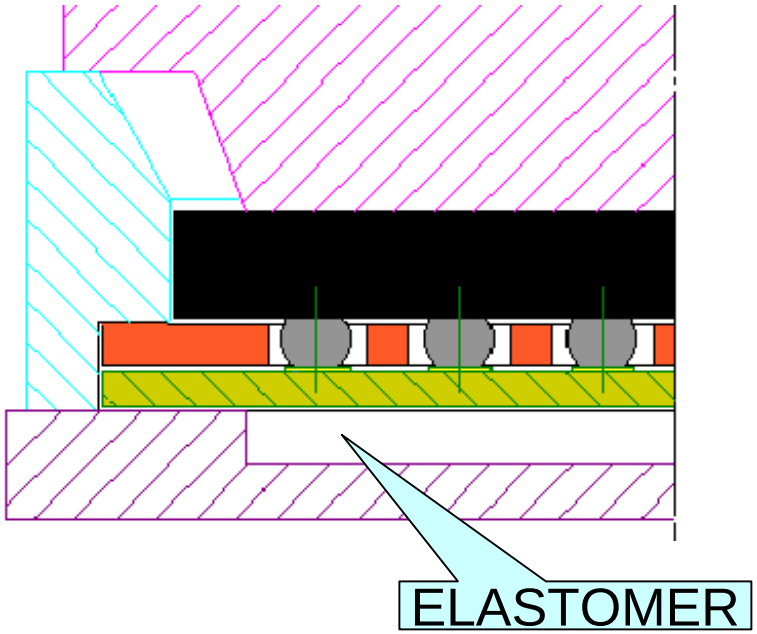
Assembly Reliability

B/I less	150deg.-C for 2h
 90um	 90um

Cross section of mounted CSP256pin

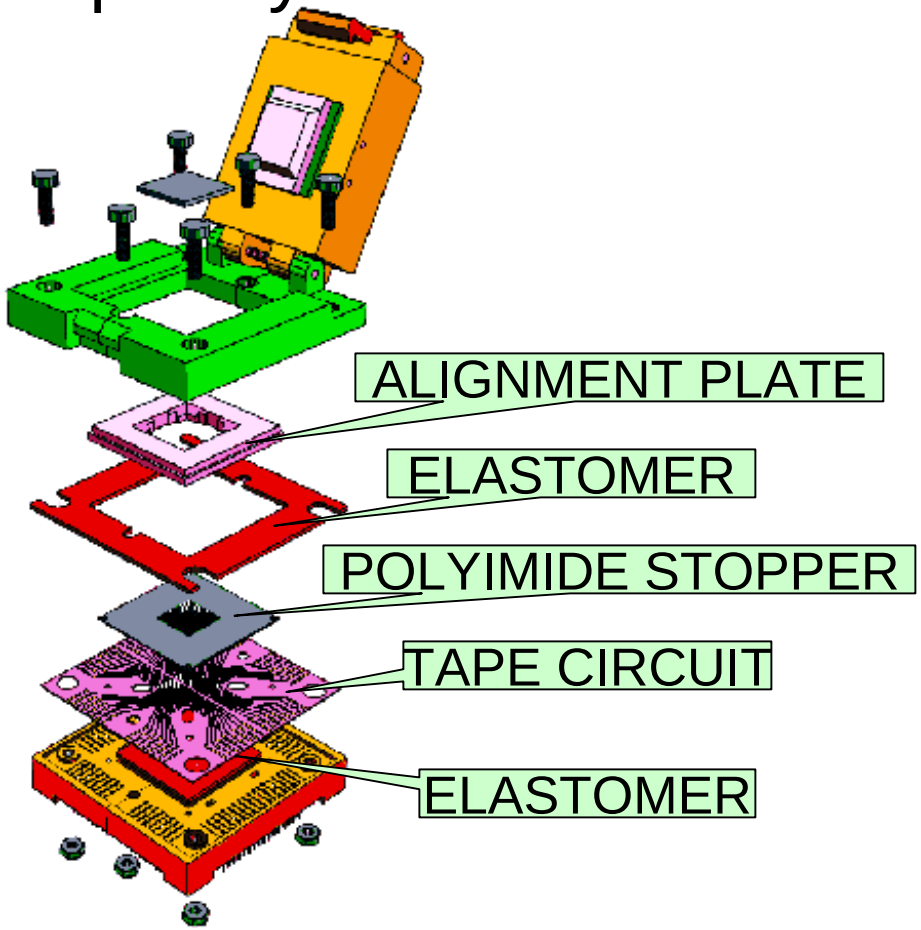
Socket Technology
Absorption for Uneven Solder Ball Height

- Appropriate Contact Force
- Elastomer Application



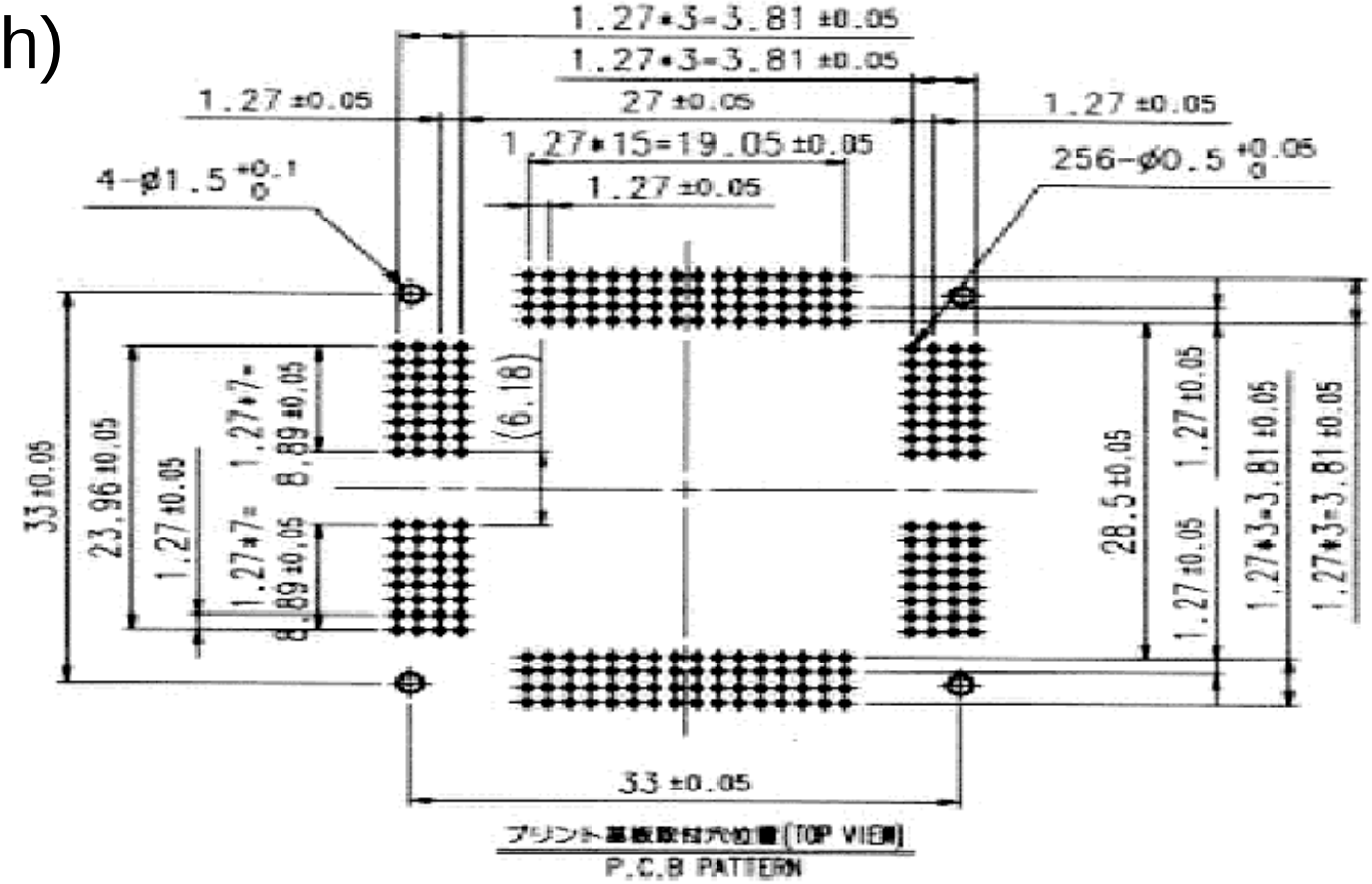
Socket Technology
Accurate Alignment on Socket Assembly

- Accurate alignment on socket assembly can realize by using multiple layer method.



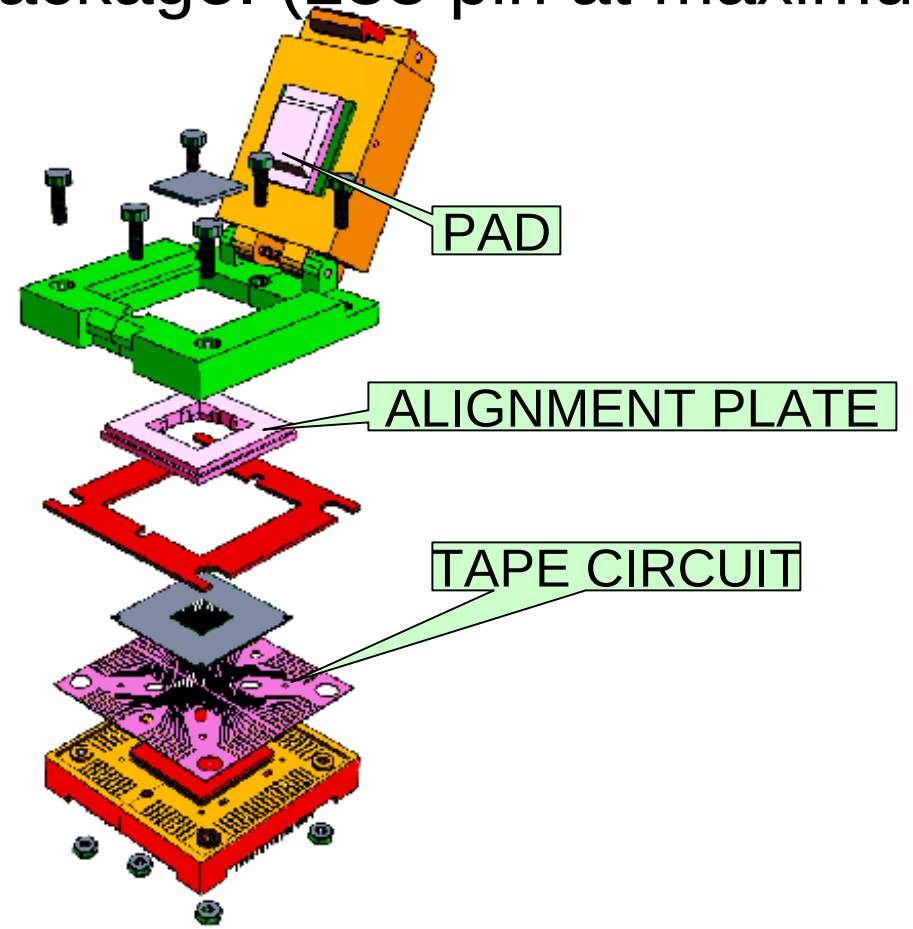
Socket Technology
Tape Circuit Fanned-out

- 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

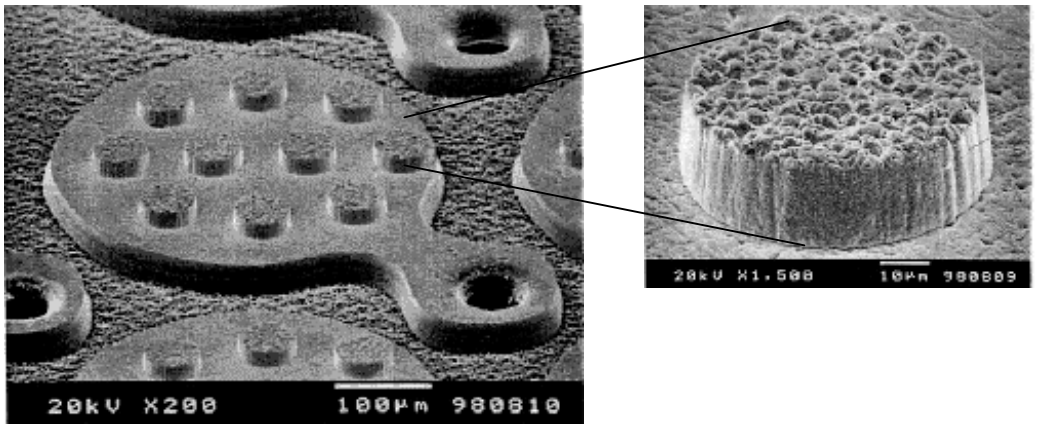
- BGA-288-0.5 Series
- BGA-288-0.4 Series Plan
- BGA-420-0.5 Series Plan
- BGA-420-0.4 Series Plan
- BGA-676-0.5 Series Plan
- BGA-676-0.4 Series Plan

Socket Cost Reduction
BGA-288-0.5 Series Lineup

PKG Size	Grid		Full	5row	4row	3row	2row
6	11	11	121	120	112	96	72
7	12	12	144	140	128	108	80
7	13	13	169	160	144	120	88
8	14	14	196	180	160	132	96
8	15	15	225	200	176	144	104
9	16	16	256	220	192	156	112
9	17	17	289	240	208	168	120
10	18	18	324	260	224	180	128
10	19	19	361	280	240	192	136
11	20	20	400	300	256	204	144
11	21	21	441	320	272	216	152
12	22	22	484	340	288	228	160
12	23	23	529	360	304	240	168
13	24	24	576	380	320	252	176
13	25	25	625	400	336	264	184
14	26	26	676	420	352	276	192
14	27	27	729	440	368	288	200
15	28	28	784	460	384	300	208
15	29	29	841	480	400	312	216
16	30	30	900	500	416	324	224
16	31	31	961	520	432	336	232
17	32	32	1024	540	448	348	240
17	33	33	1089	560	464	360	248
18	34	34	1156	580	480	372	256
18	35	35	1225	600	496	384	264
19	36	36	1296	620	512	396	272
19	37	37	1369	640	528	408	280
20	38	38	1444	660	544	420	288

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

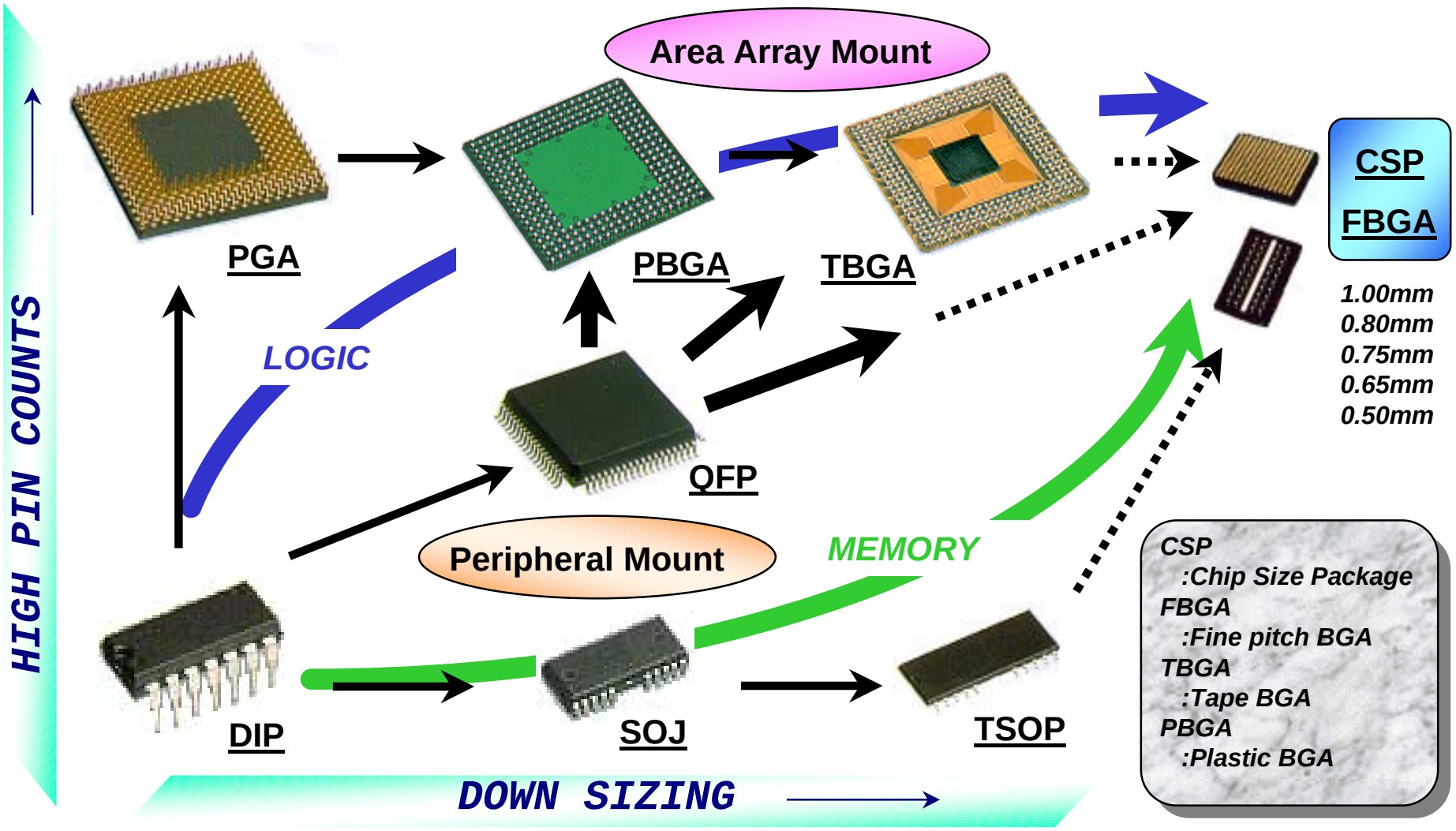
Ron Revell
Laboratory Manager
Austin, TX

Outline

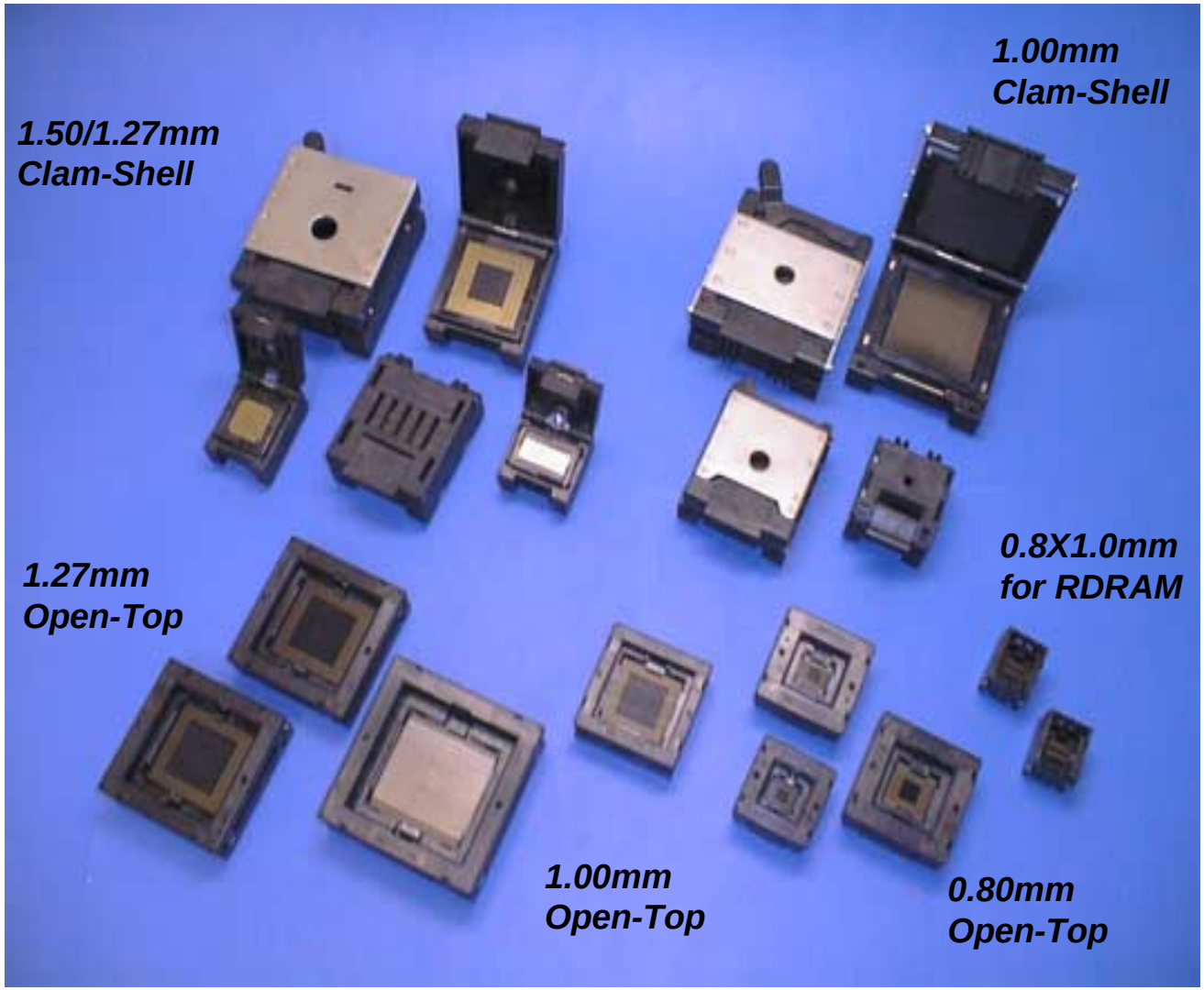
- The Problem
  - Pitch
  - Signal Integrity
- Design Objectives
- Design Features
- Design Evaluation

The Problem

IC Package Trends



3M BGA/LGA SOCKET



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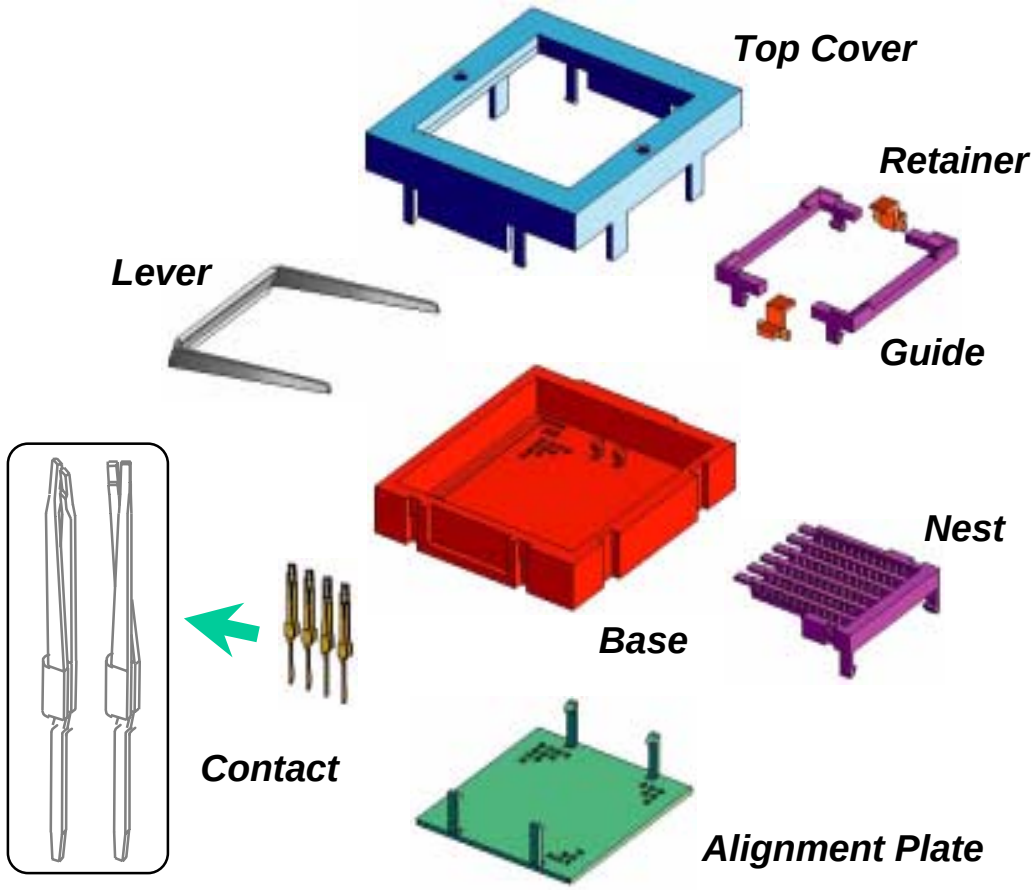
SOCKET CONSTRUCTION



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

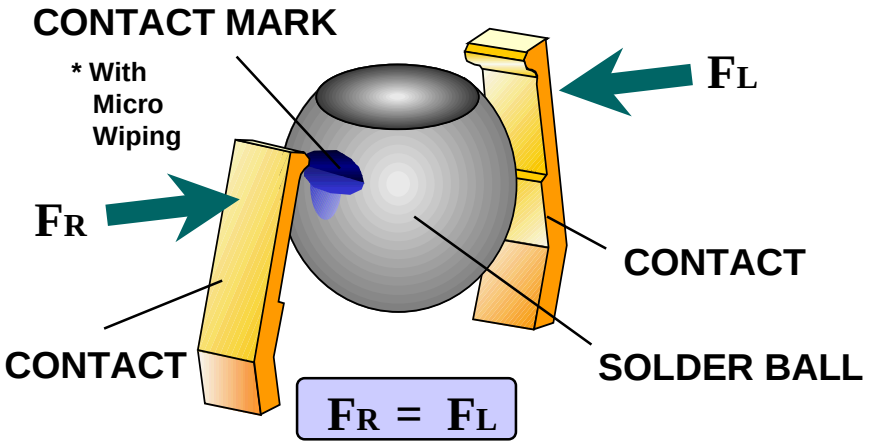
Other Metal Parts :

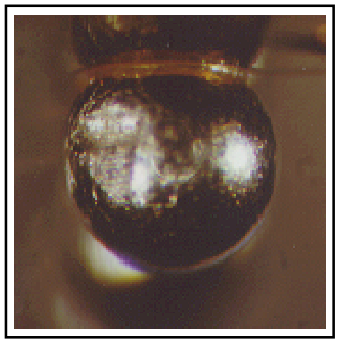
Material : Stainless Steel

Marking :

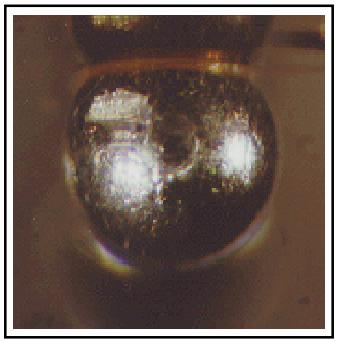
3M Logo / Textool Logo
Pin #1 Indicator / Part No.

CONTACT CONCEPT

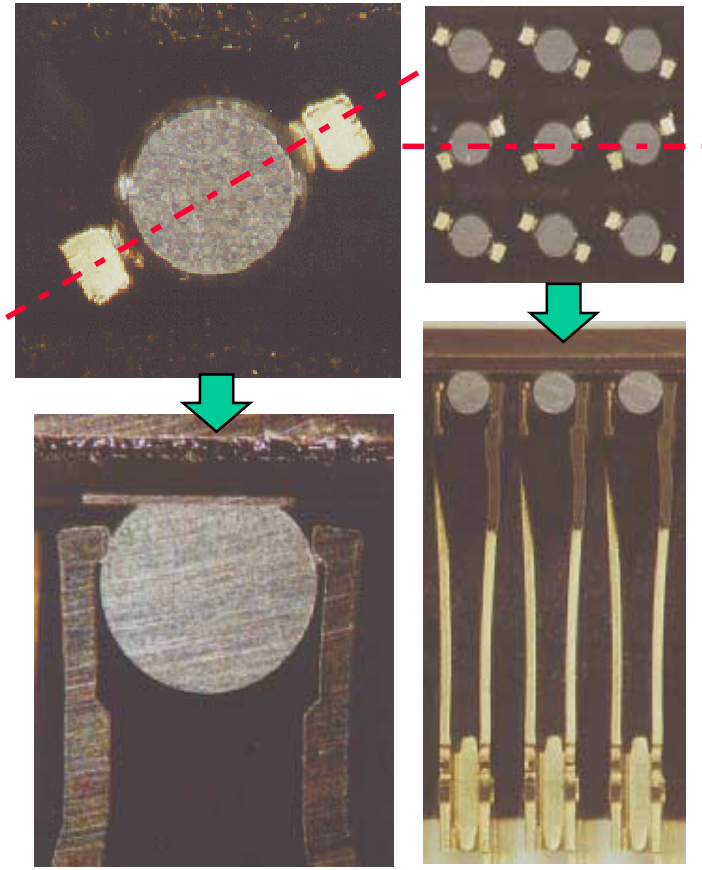




150 degree C. 48hrs.



125 degree C. 48hrs.



Solder Ball Deformation of 1.27mm O/T

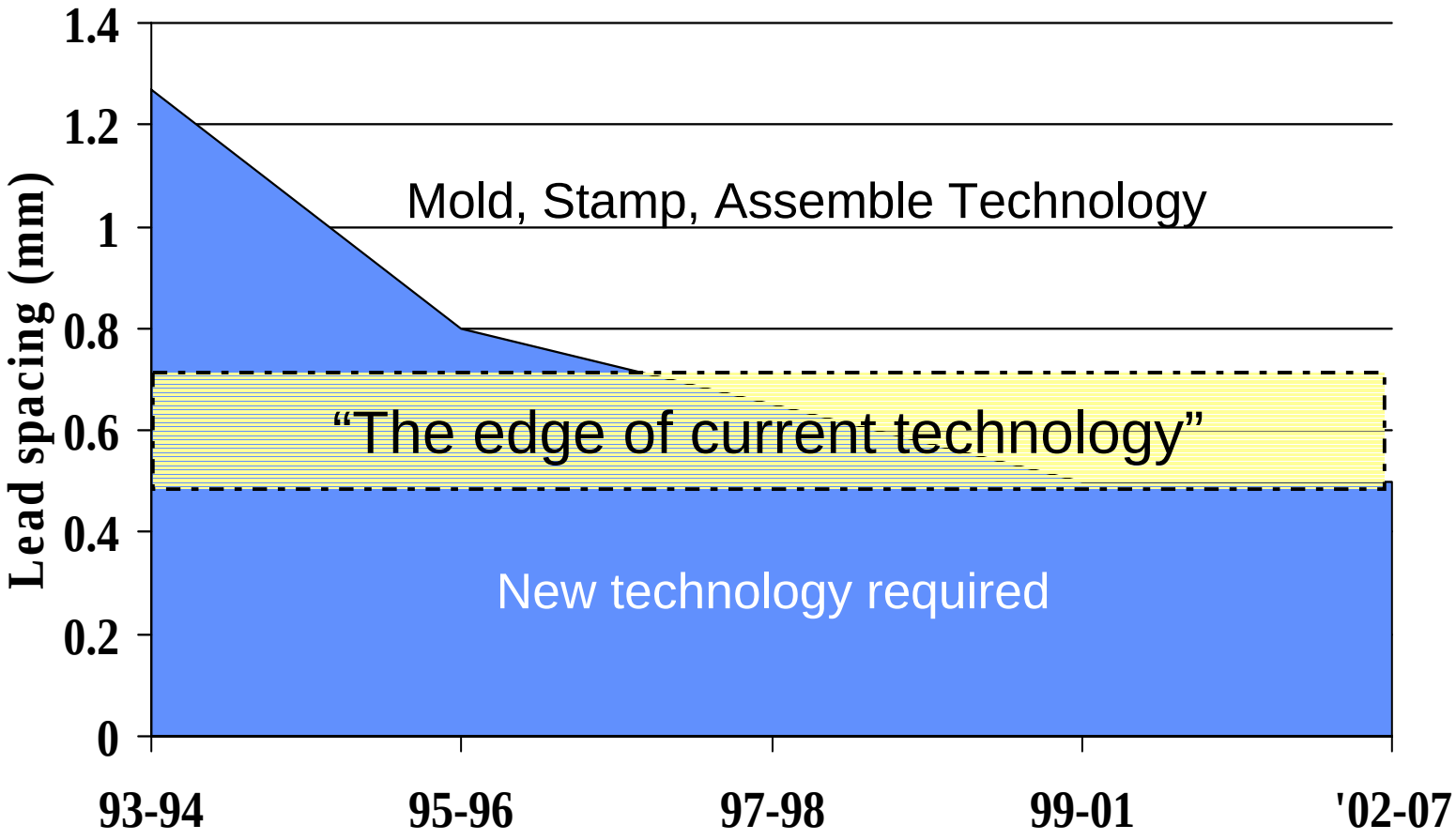
Pitch Reduction

Technology Drivers

Size reduction
device size
lead pitch
area array

Signal integrity
processor speed
voltage level
voltage margin

Wafer Level Process



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

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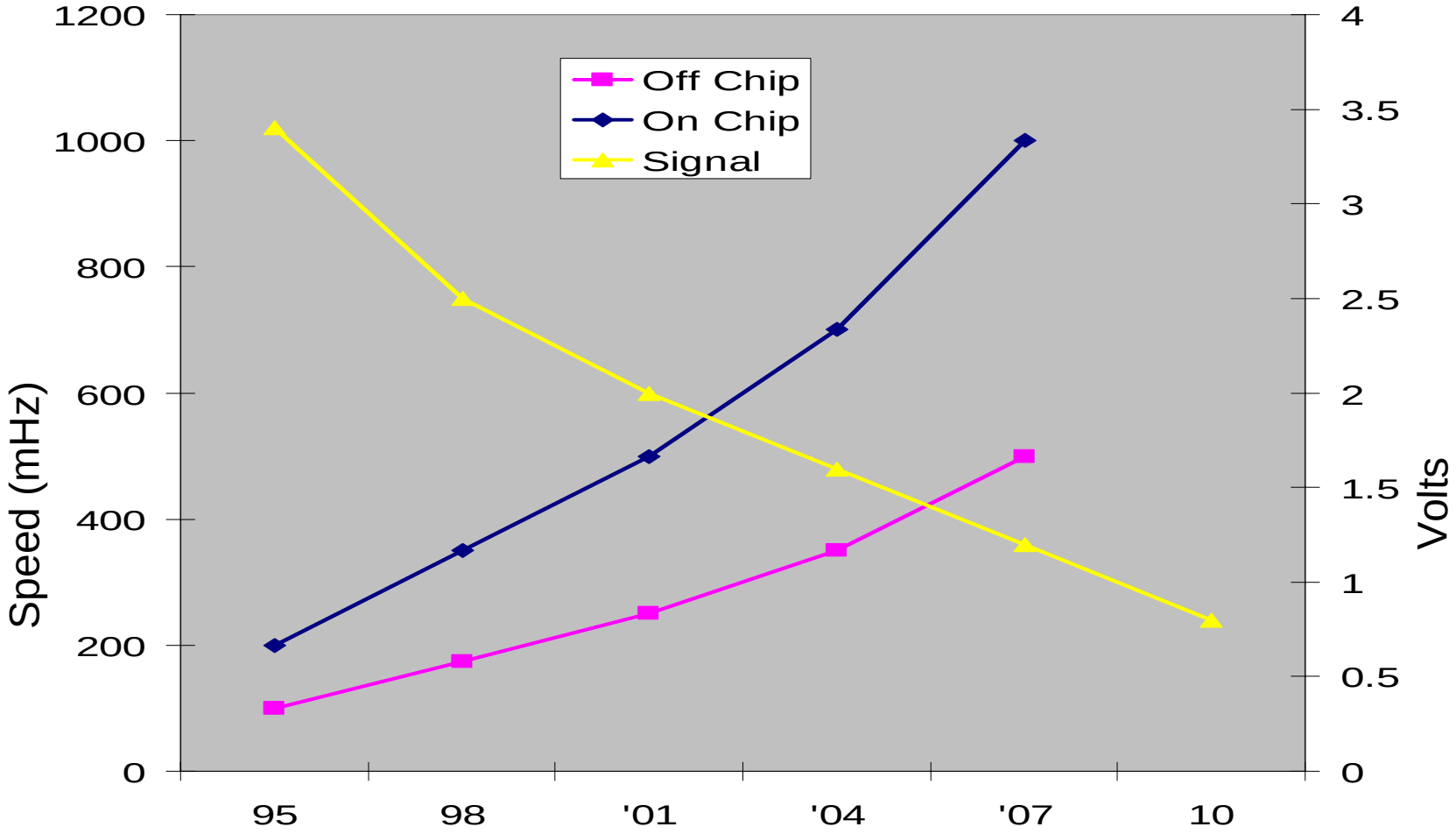
Signal Integrity Drivers



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

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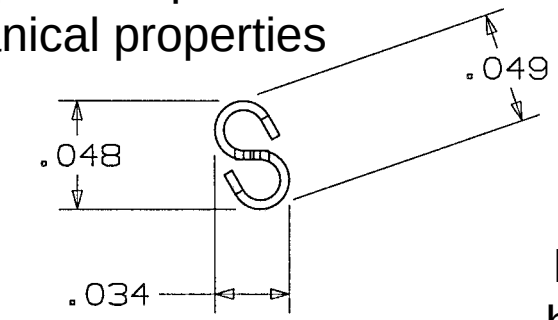
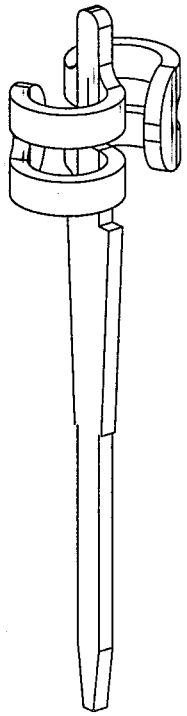
Current Technology Limitations

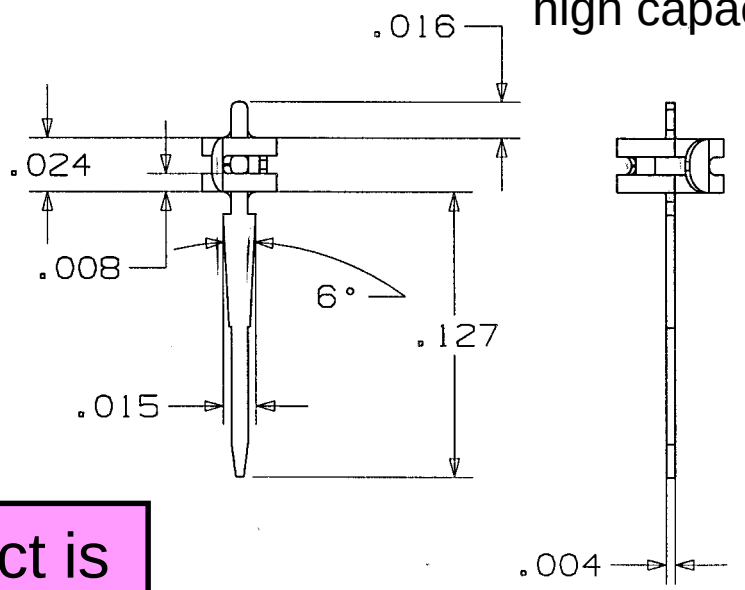
Complex shape for mechanical properties



Long signal path = high inductance



Parallel shape = high capacitance



Very thin material limited strength

This contact is 2X size needed

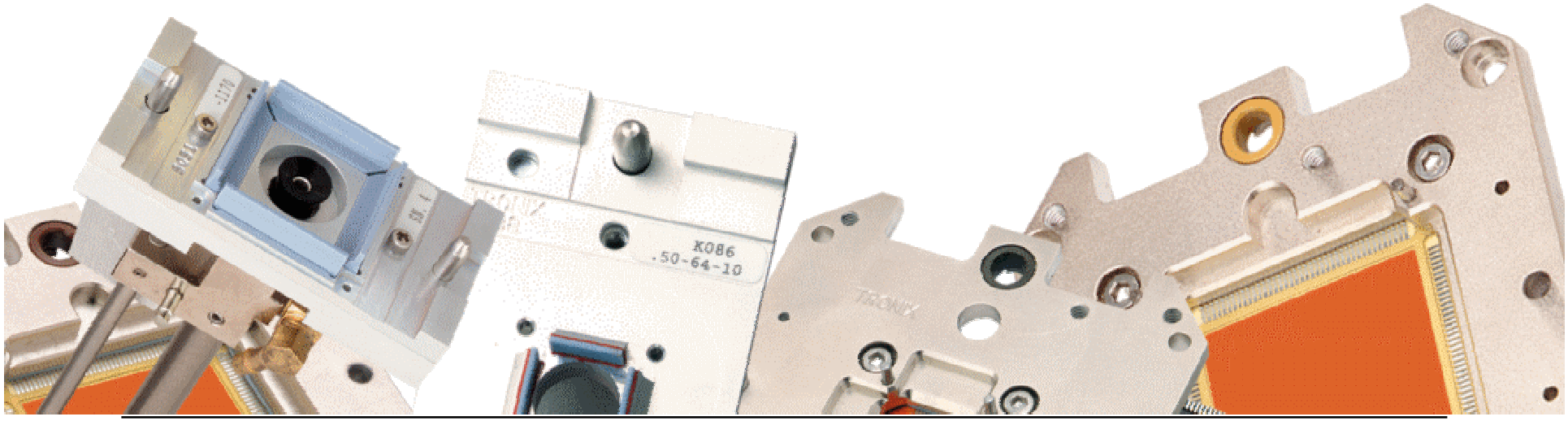
Why New Technology?

- 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



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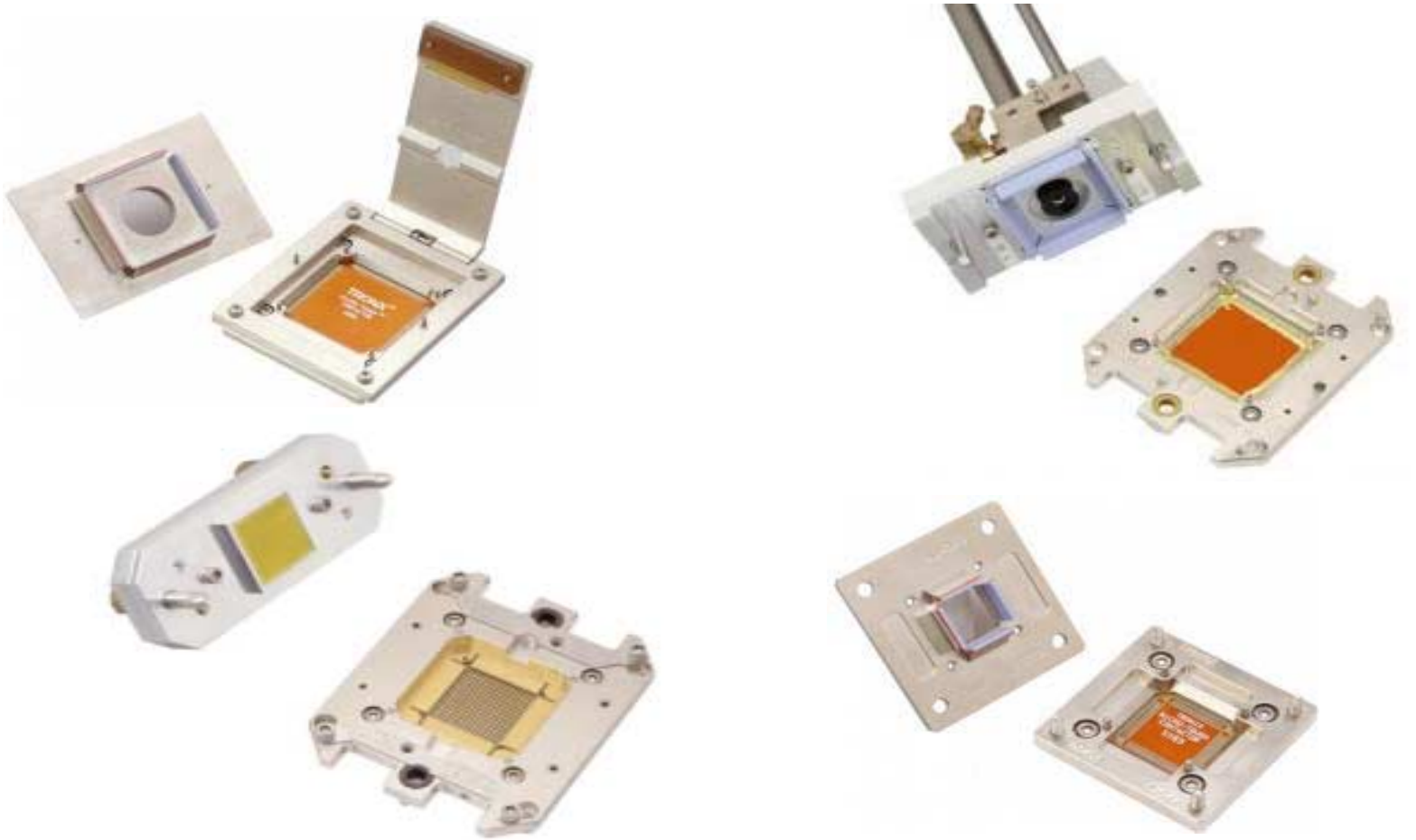
Design Objectives

- Size
- Signal Integrity
- Mechanical Durability

MicroTouch™ Products
Characterization to Final Test



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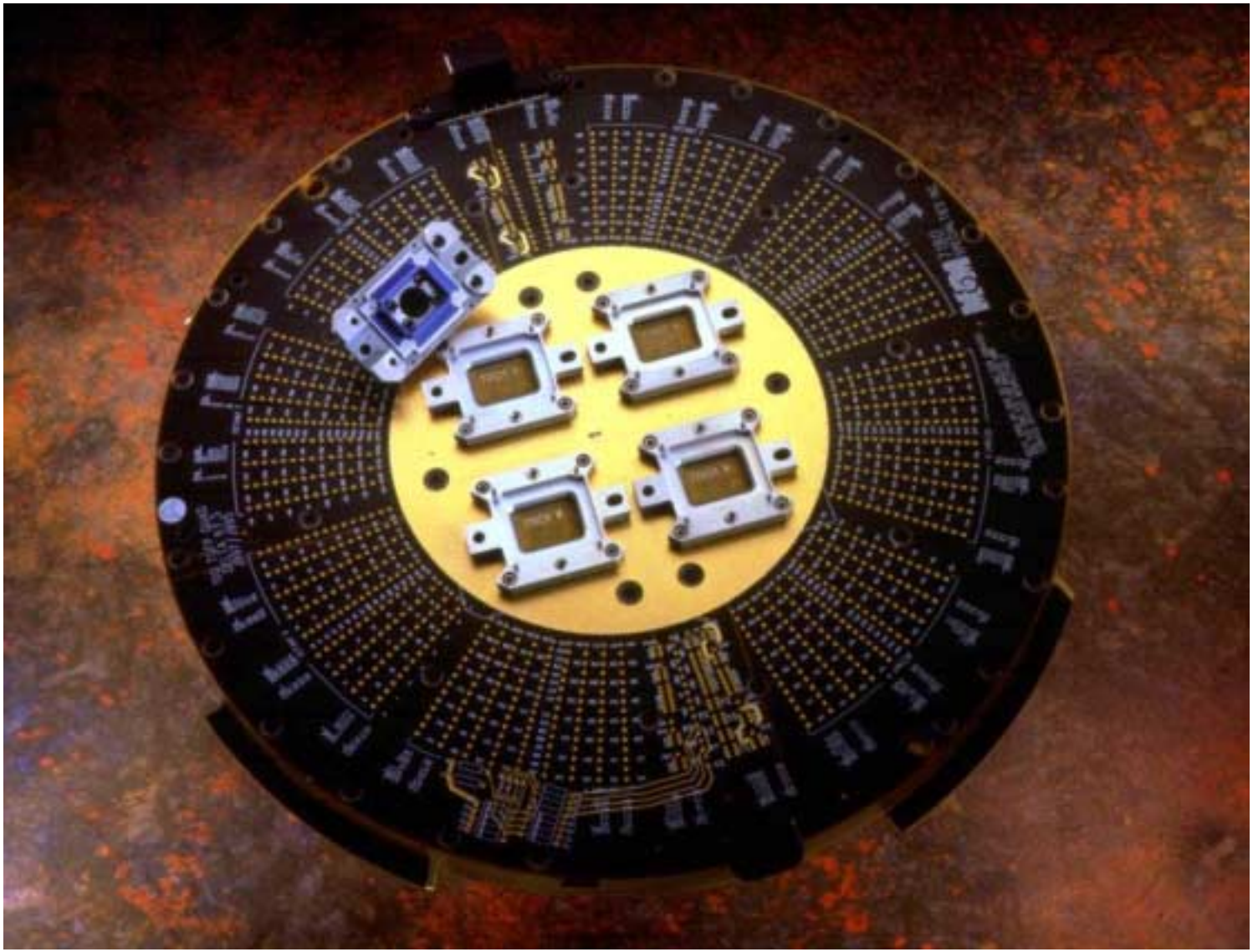
3M Innovation

MicroTouch™ Automation



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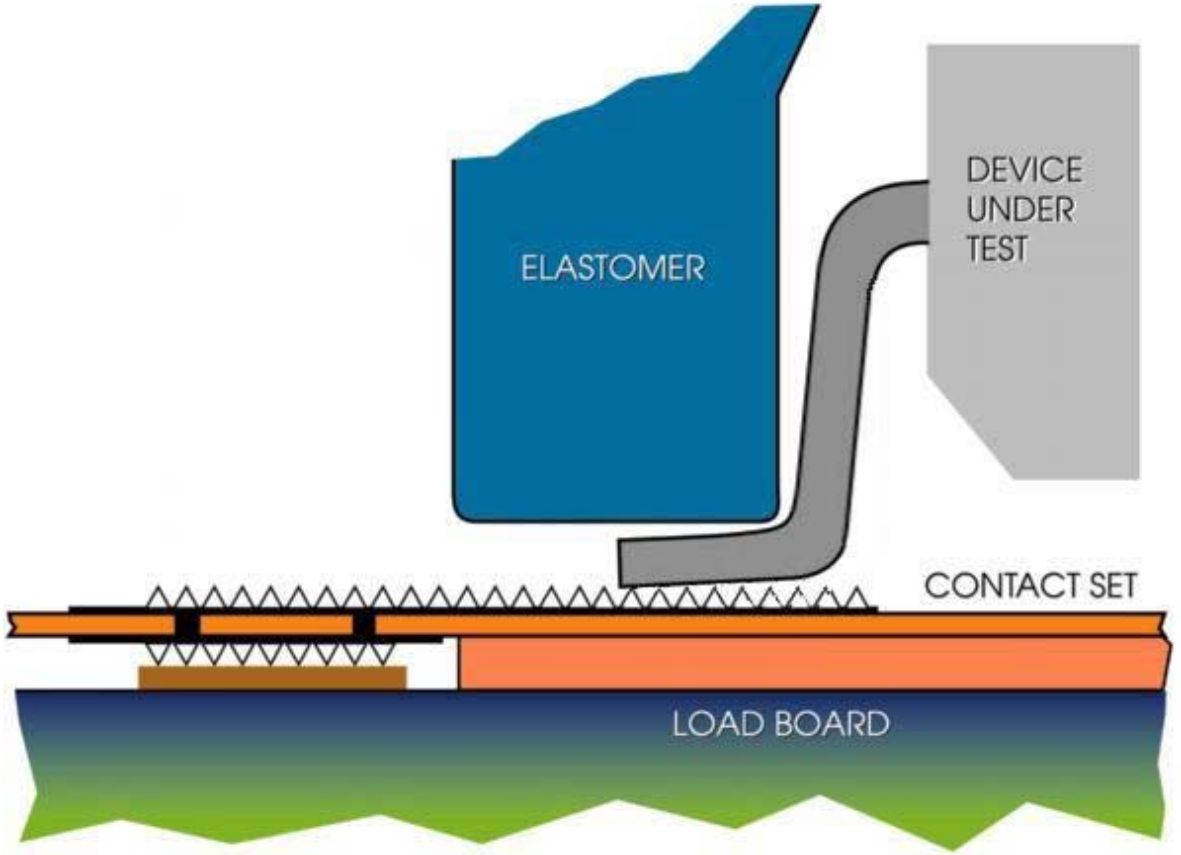
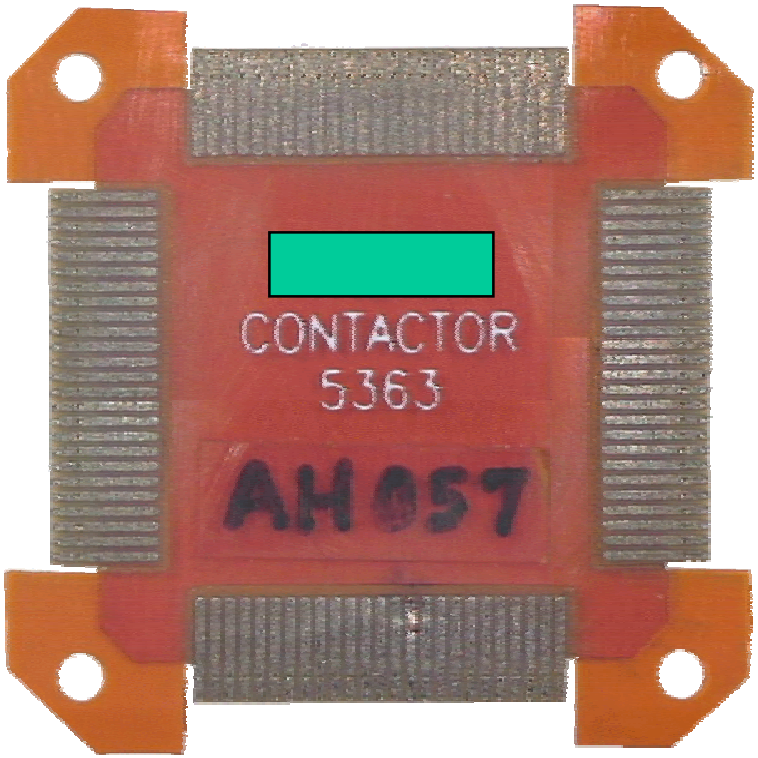
Design Features

- Contact Mechanism
- Signal Path
- Adaptability

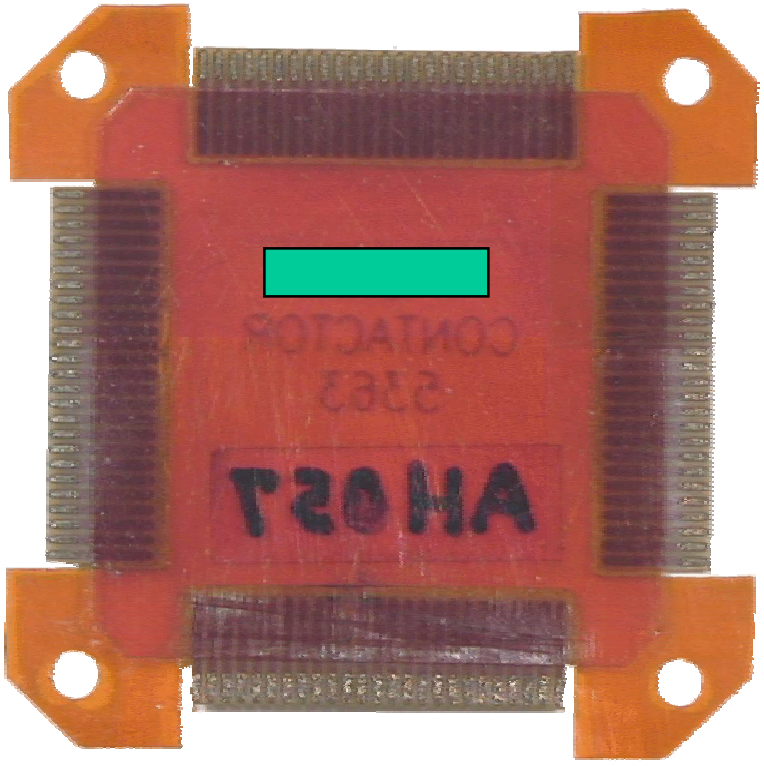
MicroTouch™ Compliant Leads



MicroTouch™ Compliant Leads Contact Set



Top or device side

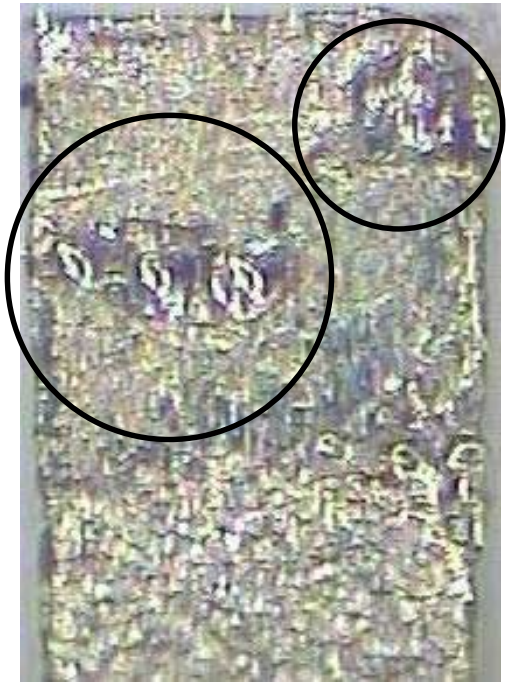


Back or load board side

MicroTouch™ Compliant Leads Contact Set

- Piercing contact
  - Oxide penetration
  - No wipe
  - Multiple contact points
- Long life
  - Hard particles
  - Easy to clean

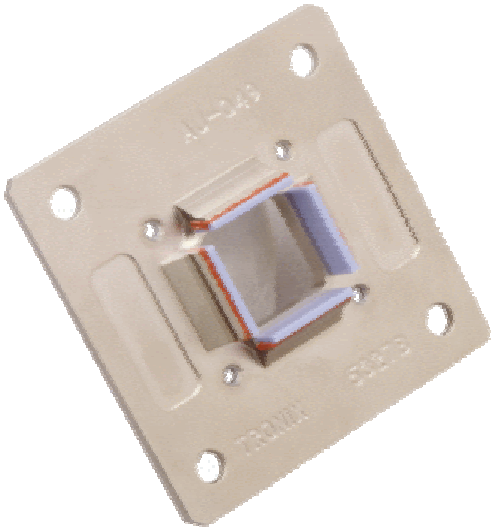
Contact set



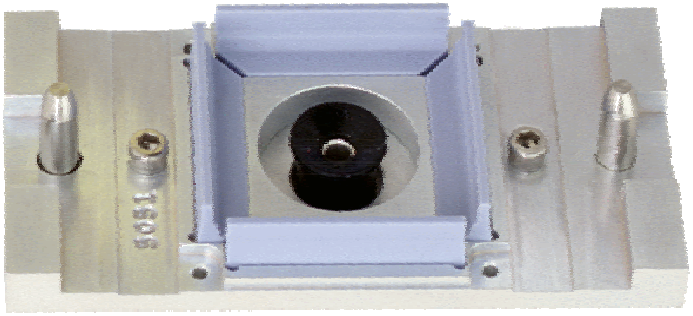
Device lead

MicroTouch™ Compliant Leads Elastomeric Nest

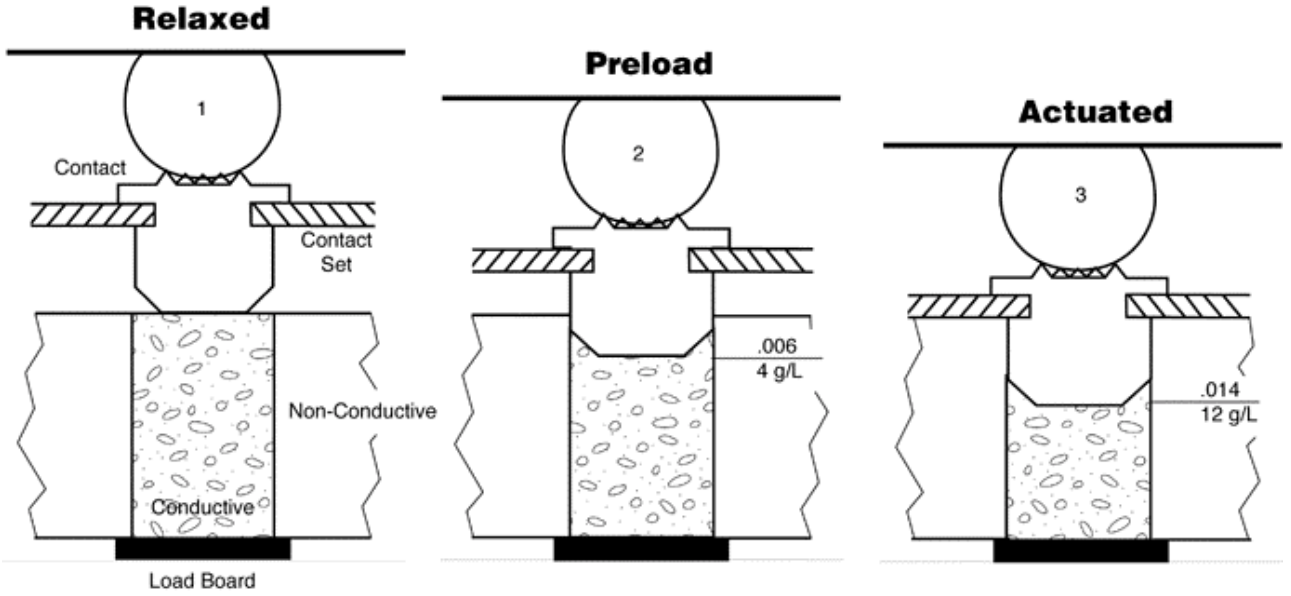
Slab style rubber
for TQFP



Full rubber fins
for QFP, CQFP



MicroTouch™ Area Grid Arrays Operation



Electronic Handling & Protection Division

3M Innovation

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