BiTS Burn-in & Test Socket Workshop 2010

Session 1

ARCHIVE 2010

SOCKET DESIGN, YOU WANT WHAT?

Development of a 33Ghz Final Test Socket
Fred Megna, Hidekazu "Hide" Miura—MJC Electronics Corporation

Socket Designs That Save Money
Mike Ramsey, Larry Furman—Plastronics Socket Company

Challenges of Test on Balls at Burn-in
Roland Muwanga, Bimal Shah, Todd Coons—Intel Corporation

An Adaptable Test Socket Concept that Meets Both the Test and Burn-In Needs of 21st Century Array Packages
Alexander Barr—3M Company
Akihiko Furuta, Masahiko Kobayashi, Yoshihisa Kawate—Sumitomo 3M Ltd.

Development of a 33Ghz Final Test Socket

Hidekazu “Hide” Miura , Fred Megna
MJC Electronics Corp.

2010 BiTS Workshop
March 7 - 10, 2010

Contents

Introduction

In order to obtain accurate and repeatable test results when contacting packaged ICs for high frequency / high power testing

- Minimize inductance on RF pins
- Minimize contact resistance on DC pins
- Maximize thermal conductivity
- Ability to test HVM quantities

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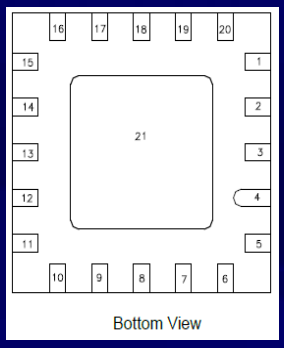
Device Specification

<u>Ka-Band 1W PA:</u>



Bottom View

- QFN 20-pin package
  - 4 x 4 x 1.2mm
  - Air Cavity Package
- Frequency Range: 28 - 31 GHz
- Saturated Output Power: 30.5dBm

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Previous Test Method

Direct plunge to board
- Good RF Performance but poor repeatability (Contact issue)
  - Burrs on package cause contact problems
  - Inconsistent contact to backside ground/thermal pad
  - Plunger force needs to be adjusted often to maintain yield
  - No contact compliance
  - PCB traces wear quickly (<10K contacts)

RF POGO Pins Contactor
- Poor RF Performance – only good to ~10GHz
  - Mutual capacitance/inductance
- DC contact improved
- Still have Thermal Issue

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Socket Specifications

- Housing Material
- Pin Type
- Housing Design

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Housing Material Selection

		Physical Properties	Units	Comments	Torlon 4203 PAI Poly-amide-imide Electrical Grade	Torlon 5530 PAJ (CM) 30% Grass Reinforced Compression Method	PEEK 450 Poly-Ethere-Ethere-Ketone (Unfilled)
MECHANICAL	1	Specific Gravity (比重)	-	D792	1.41	1.61	1.31
	2	Tensile Strength (引張強度)	psi	D638	20000 (138MPa)	15000	16000 (110MPa)
	3	Tensile Modulus (引張弾性率)	psi	D638	600000 (4136MPa)	900000	630000 (4343MPa)
	4	Elongation (伸び)	%	D638	10	3	40
	5	Flexural Strength (曲げ強度)	psi				
		…		Long Term	500	5800	480
		…		F433	1.8	2.5	1.75
ELECTRICAL PROPERTIES	23	Dielectric Strength,Short Term (絶縁耐力)	Volts/mil	D149	580	700	480
	24	Surface Resistance (体積固有抵抗)	Ohm/Square	EOS/ESD S11.11	10^{16}	10^{13}	$>10^{13}$
	25	Dielectric Constant(誘電率)	1MHz	D150	4.2	6.3	3.3
	26	Dissipation Factor	1MHz	D150	0.026	0.05	0.003
MISCELLANEOUS	27	Water Absorption Immersion,24hr (吸水率:24hr)	%	D570(2)	0.4	0.3	0.1
	28	Water Absorption Immersion Sat (吸水率:平衡)	%	D570(2)	1.7	1.5	0.5

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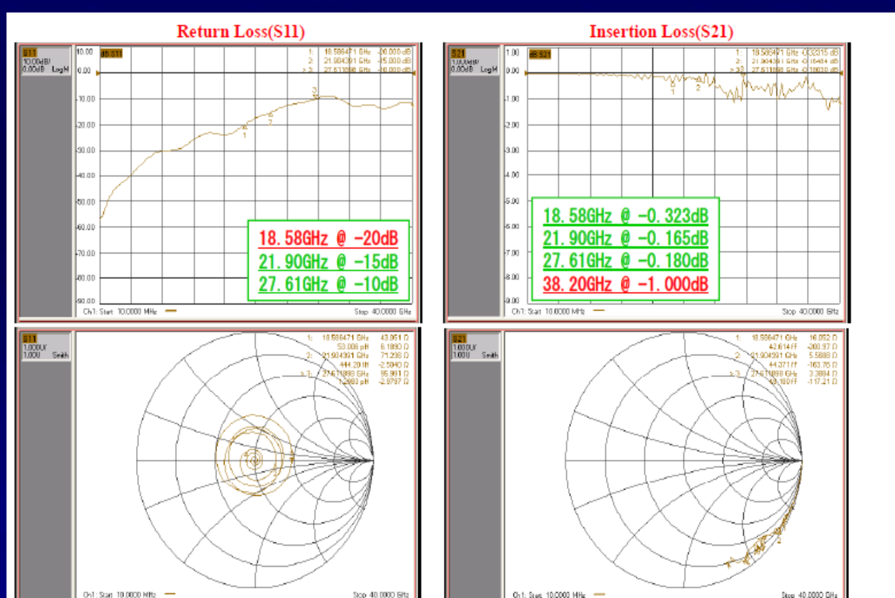
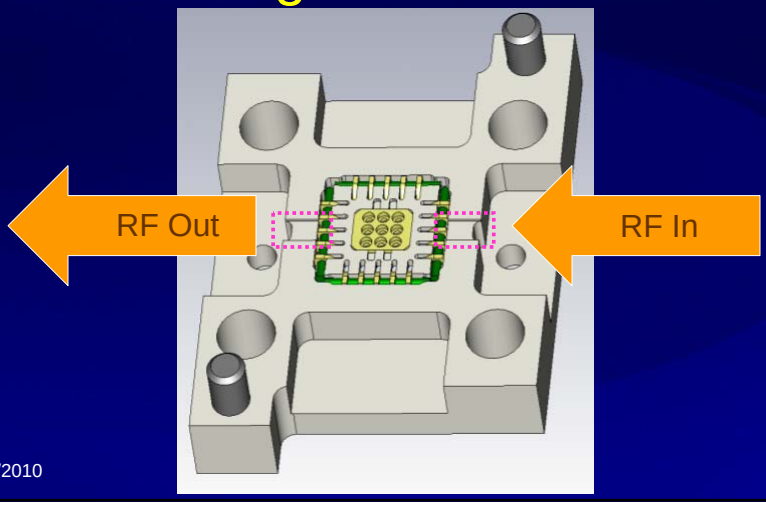
Pin Selection Type J0.5



Paper #1

Housing Design

Relieve housing material surrounding RF traces



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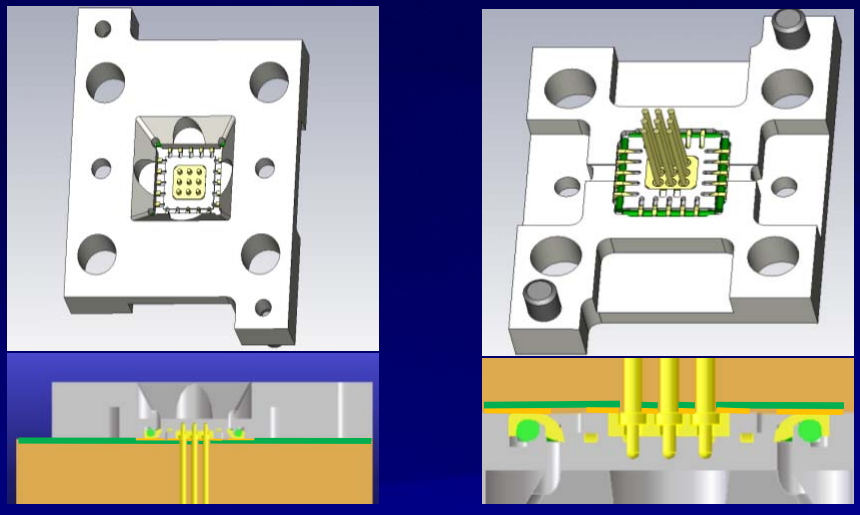
Finished Product

Handler side view

PCB Side view



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Test Result!!!

Initial Test Result: Failed?!?!?!

- Direct PTB result:
  1. Saturated output power ~30dBm
  2. Gain ~18dB
- Socket Result
  1. Saturated output power ~17dBm
  2. Gain ~4dB

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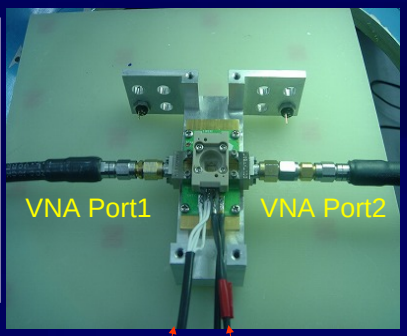
Experiment Tooling

Measuring instrument and power source

VNA: Agilent E8364B
DC Power Supply: KENWOOD PA181.2A



Frequency
10MHz～40GHz

Power Range 0dBm
25GHz～35GHz

Input power and S21, measured with Network Analyzer

S21 value will be reference for Gain

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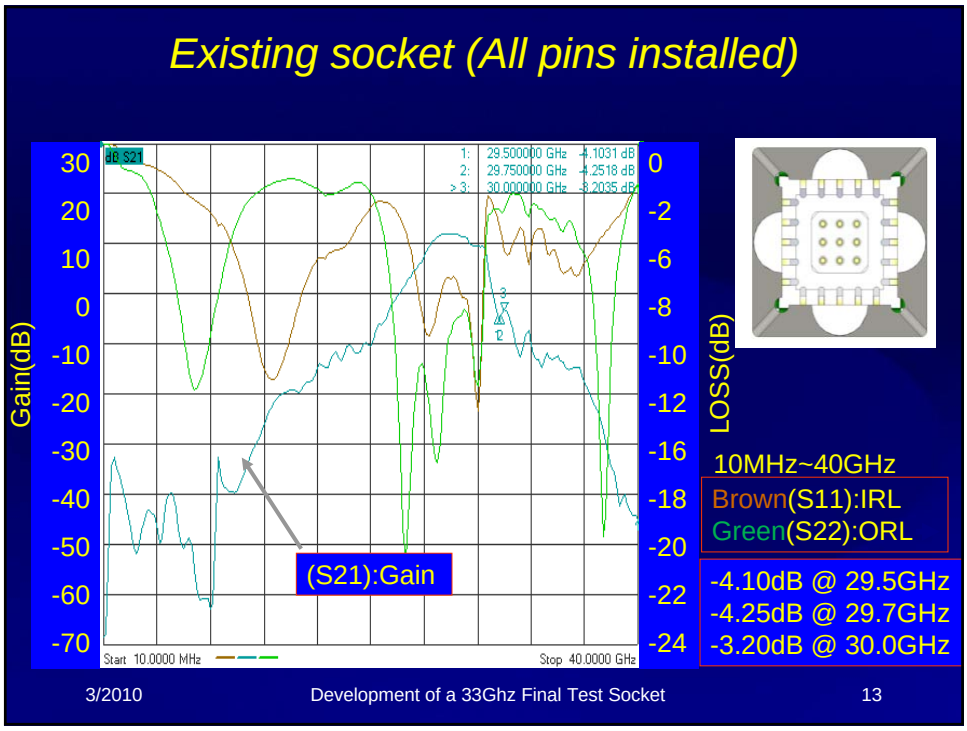
Existing socket (All pins installed)
dB S21
1: 29.500000 GHz -4.1031 dB
2: 29.750000 GHz -4.2518 dB
> 3: 30.000000 GHz -3.2035 dB
Gain(dB)
LOSS(dB)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70
0 -2 -6 -8 -10 -12 -16 -18 -20 -22 -24
(S21):Gain
Start 10.0000 MHz
Stop 40.0000 GHz
10MHz~40GHz
Brown(S11):IRL
Green(S22):ORL
-4.10dB @ 29.5GHz
-4.25dB @ 29.7GHz
-3.20dB @ 30.0GHz
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Development of a 33Ghz Final Test Socket
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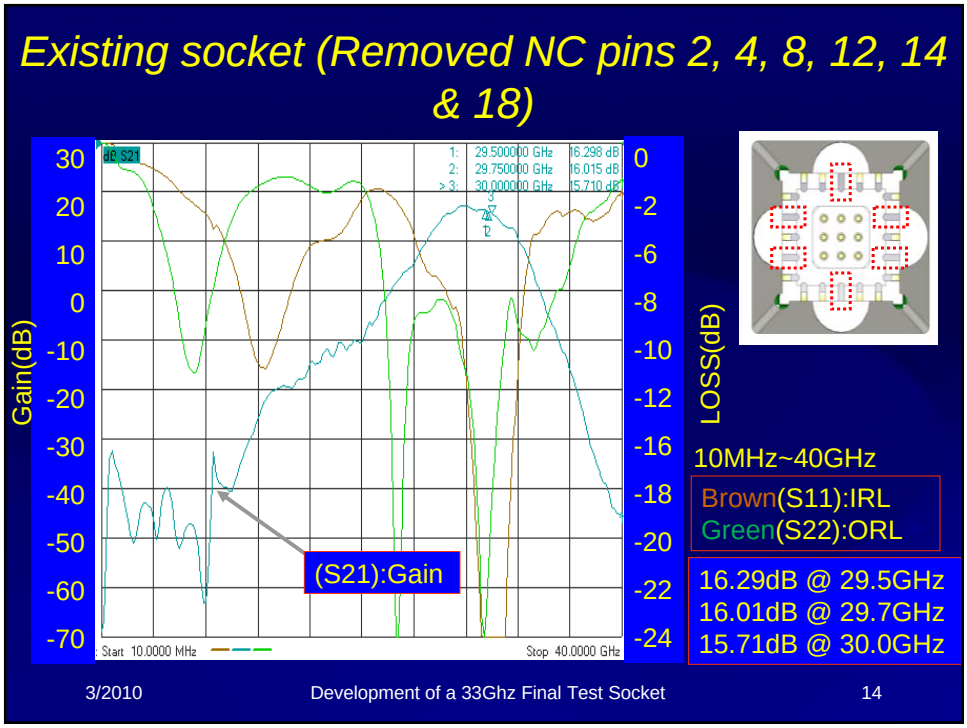
Existing socket (Removed NC pins 2, 4, 8, 12, 14 & 18)
dB S21
1: 29.500000 GHz 16.298 dB
2: 29.750000 GHz 16.015 dB
> 3: 30.000000 GHz 15.710 dB
Gain(dB)
LOSS(dB)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70
0 -2 -6 -8 -10 -12 -16 -18 -20 -22 -24
(S21):Gain
Start 10.0000 MHz
Stop 40.0000 GHz
10MHz~40GHz
Brown(S11):IRL
Green(S22):ORL
16.29dB @ 29.5GHz
16.01dB @ 29.7GHz
15.71dB @ 30.0GHz
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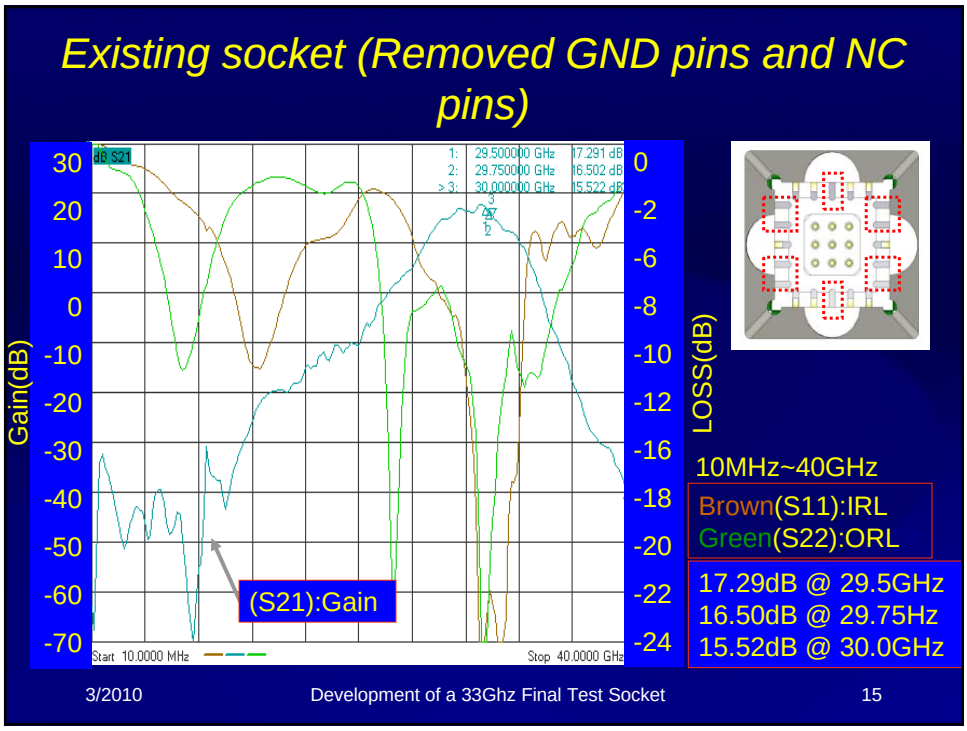
Existing socket (Removed GND pins and NC pins)
dB S21
1: 29.500000 GHz 17.291 dB
2: 29.750000 GHz 16.502 dB
> 3: 30.000000 GHz 15.522 dB
30 20 10 0 -10 -20 -30 -40 -50 -60 -70
0 -2 -6 -8 -10 -12 -16 -18 -20 -22 -24
Gain(dB)
LOSS(dB)
(S21):Gain
Start 10.0000 MHz
Stop 40.0000 GHz
10MHz~40GHz
Brown(S11):IRL
Green(S22):ORL
17.29dB @ 29.5GHz
16.50dB @ 29.75Hz
15.52dB @ 30.0GHz
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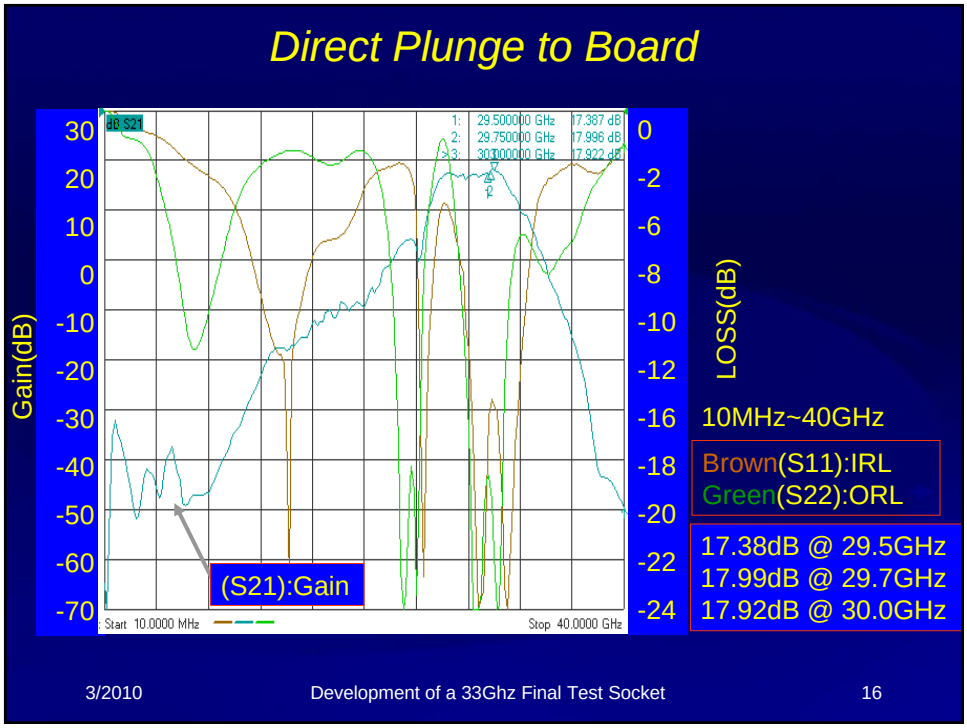
Direct Plunge to Board
dB S21
1: 29.500000 GHz 17.387 dB
2: 29.750000 GHz 17.996 dB
> 3: 30.000000 GHz 17.922 dB
30 20 10 0 -10 -20 -30 -40 -50 -60 -70
0 -2 -6 -8 -10 -12 -16 -18 -20 -22 -24
Gain(dB)
LOSS(dB)
(S21):Gain
Start 10.0000 MHz
Stop 40.0000 GHz
10MHz~40GHz
Brown(S11):IRL
Green(S22):ORL
17.38dB @ 29.5GHz
17.99dB @ 29.7GHz
17.92dB @ 30.0GHz
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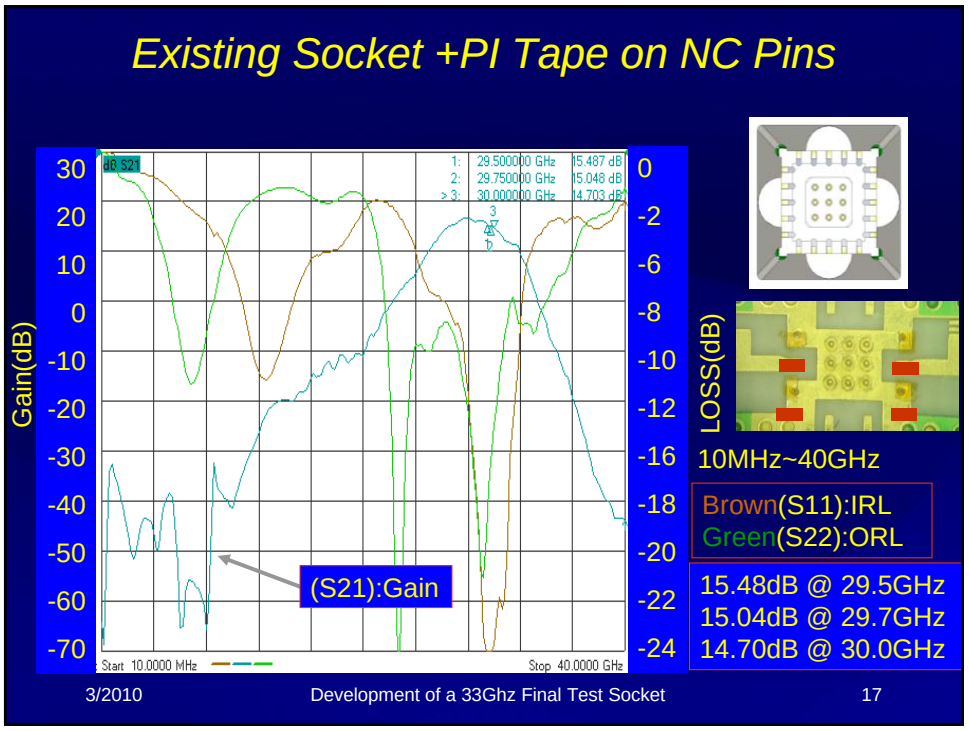
Existing Socket +PI Tape on NC Pins
Gain(dB)
LOSS(dB)
(S21):Gain
10MHz~40GHz
Brown(S11):IRL
Green(S22):ORL
15.48dB @ 29.5GHz
15.04dB @ 29.7GHz
14.70dB @ 30.0GHz
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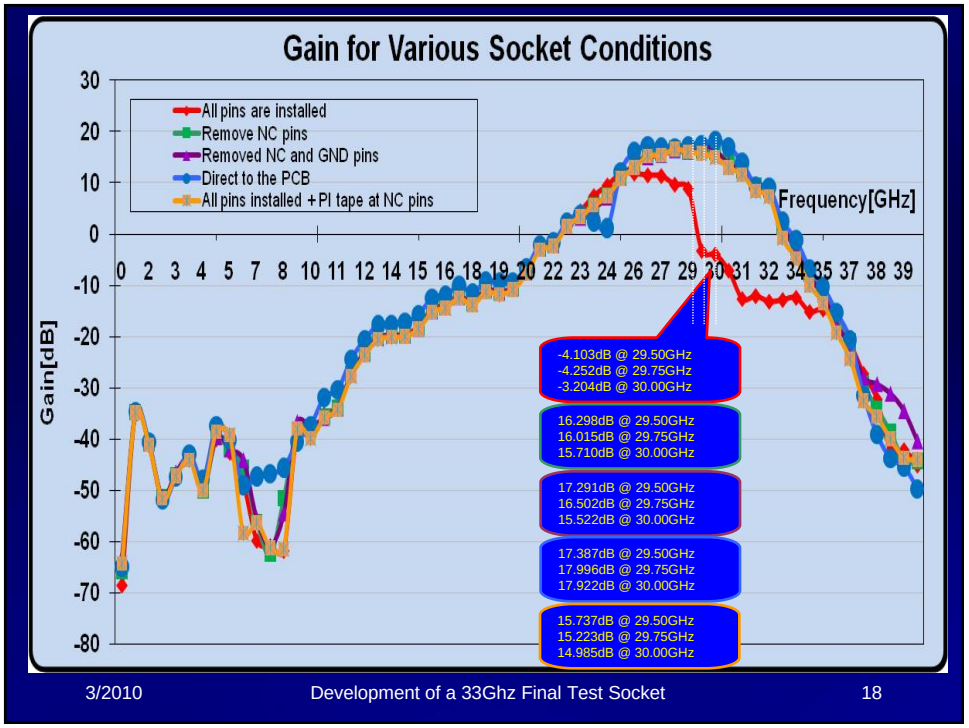
Gain for Various Socket Conditions
All pins are installed
Remove NC pins
Removed NC and GND pins
Direct to the PCB
All pins installed +PI tape at NC pins
Frequency[GHz]
Gain[dB]
-4.103dB @ 29.50GHz
-4.252dB @ 29.75GHz
-3.204dB @ 30.00GHz
16.298dB @ 29.50GHz
16.015dB @ 29.75GHz
15.710dB @ 30.00GHz
17.291dB @ 29.50GHz
16.502dB @ 29.75GHz
15.522dB @ 30.00GHz
17.387dB @ 29.50GHz
17.996dB @ 29.75GHz
17.922dB @ 30.00GHz
15.737dB @ 29.50GHz
15.223dB @ 29.75GHz
14.985dB @ 30.00GHz
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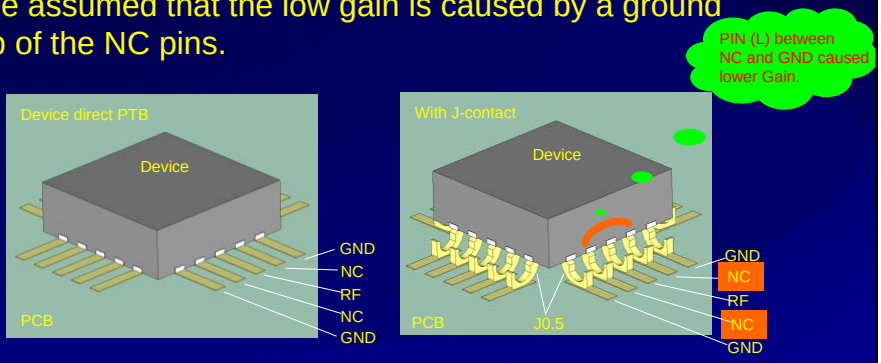
Summary:

- When all pins are installed in the socket, Gain is low.
- When NC and GND pins are removed, Gain is similar to PTB.

Comments:

- We assumed that the low gain is caused by a ground loop of the NC pins.



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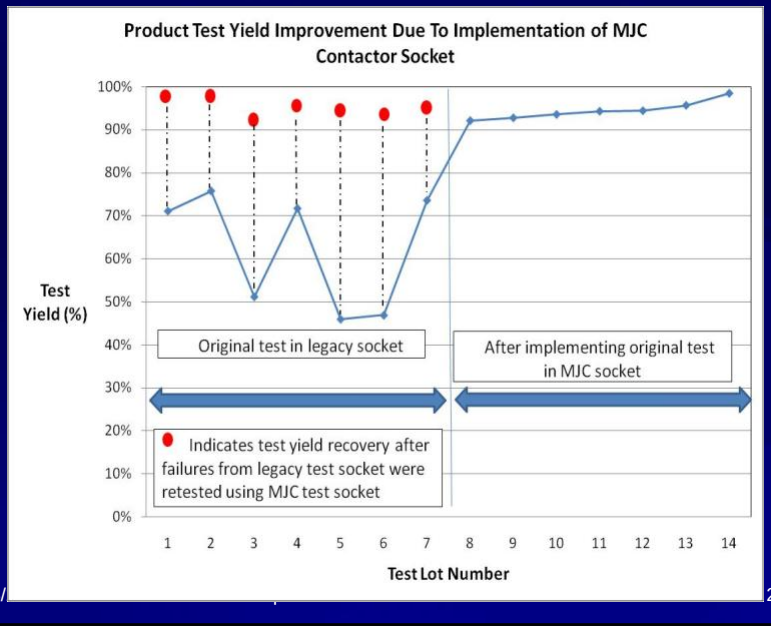
Final Test Results



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Conclusion

- Resolved contact issue
- Device burrs are not an issue
- Constant plunger force, good for air cavity package
- Easy to characterize S parameters
- PCB trace wear is greatly reduced
- Yield is stable
- Able to concentrate to find problems from process/assembly

Acknowledgements

Contributors	MJC
Howard Kuan	PP Engineering Dept.
Brian Dabrowski	
Jeffrey Baldwin	

Socket Designs That Save Money

Mike Ramsey - Plastronics
Larry Furman - Plastronics

2010 BiTS Workshop
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PLASTRONICS

Agenda

- Socket Design – The BiTS Decade
- The Problem with Current Strategies
- A Superior Solution
- Changing the Way You do Business

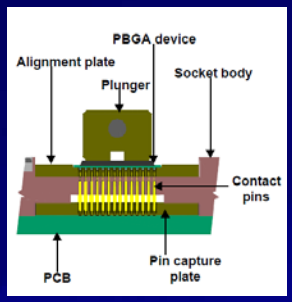
Socket Design at BiTS

BiTS 2000

Socket Structure

Operating Conditions

Anatomy of the socket: contacts, insulator, force mechanism bound by operational constraints



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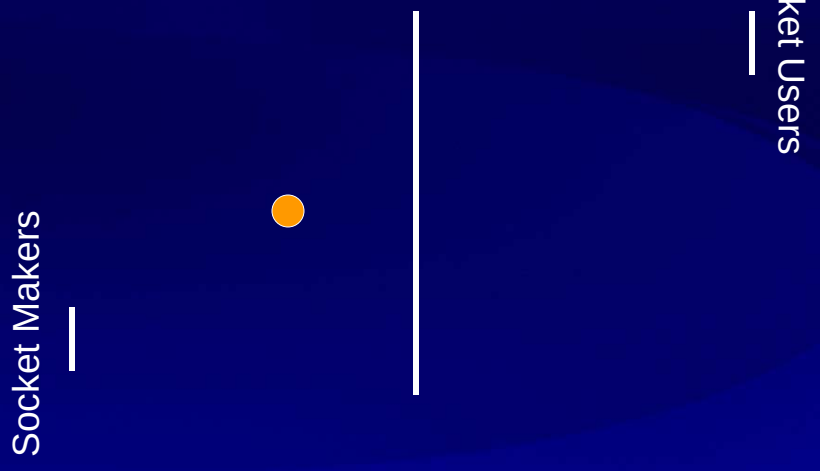
What are Operational Constraints?

Game Theory



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Operational Constraints...

Tit for Tat

Socket Makers

- Contact Technology
  - Performance
    - Style
    - Length
    - Components
  - Manufacturing
    - Stamping
    - Screw Machine
    - Drawn
    - Etched
- Insulator/Socket Base
  - Material
    - Molded Plastic
    - Machined Plastic
    - Drilled PCB
    - Ceramic
  - Performance
    - High Temperature
    - ESD
    - Durability
- Force Mechanism
  - Materials
  - Design
    - Pin Count
    - Package Size
    - Thermal

Socket Users

- Socket Type
  - Open Top
  - Clam Shell
  - Modified
- Socket Performance
  - Signal Integrity
  - Current Rating
  - Temperature Rating
  - Cycle Life
  - Thermal Management
  - Repairable
- Volume
  - Small: 1 to 10
  - Low: 25 to 1,000
  - Medium: 5,000 to 25,000
  - High: 50,000+
- Tooling
  - NRE Upfront
  - Amortized
  - No Tooling
- Delivery
  - Now
  - 4 weeks
  - 10+ weeks
- Price
  - Too Much

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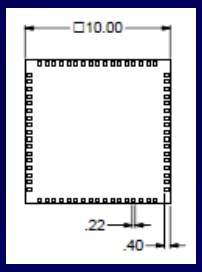
Socket Design

EXPECTATIONS

Specification
(Constraints)



10X10 Package
68 Pad QFN
0.5mm Pitch
Variable Thickness
Surface Mount
Burn-in Plus
Board Density
Cost

COMPRIMISE

Permutations
(Latin Squares)

1	2	3
2	3	1
3	1	2

Components
Socket Design
Design to Cost
Manufacturing
Pricing
Delivery

BALANCE

Part Number
(Solution)
68QHC50A11010

Clam Shell
Performance Contact
Spring Loaded Plunger
Low Profile Footprint

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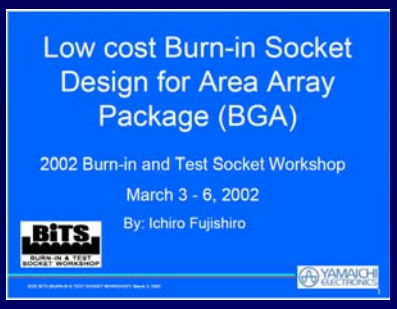
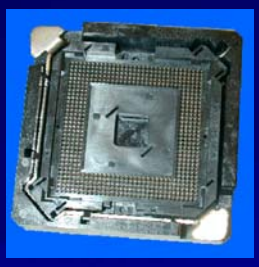
Socket Cost Reduction at BiTS

BiTS 2002



Component Count Reduction

Transfer of Functionality



Anatomy of the socket: contacts, insulator, force mechanism bound by operational constraints

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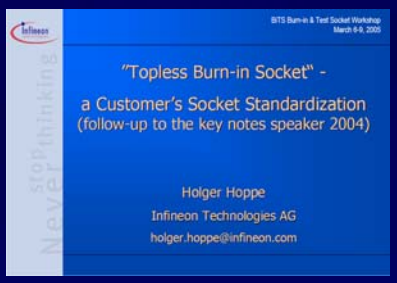
Socket Cost Reduction at BiTS

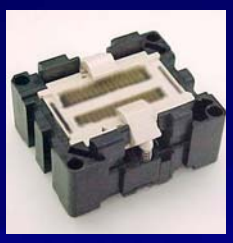
BiTS 2005



Component Count Reduction

Transfer of Functionality

Flexibility / Standardization



Anatomy of the socket: contacts, insulator, force mechanism bound by operational constraints

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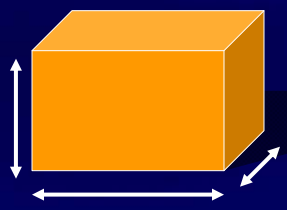
Socket Cost Reductions

Limited Solution



Thought process is still bound by X,Y,Z socket solutions

Component Reduction versus Transfer of Functionality

Component Reduction is a savings, but limited...can only remove so much

Still have a dedicated part number... the next application means step & repeat the whole process

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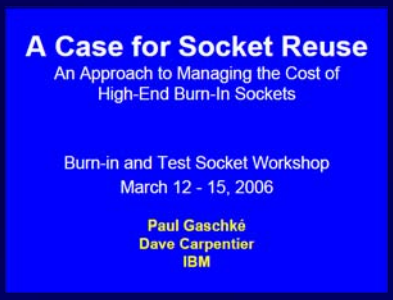
Reusable Sockets at BiTS

BiTS 2006

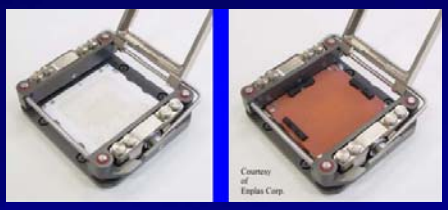


Flexible Socket Design

Reusable Hardware

Reconfigurable Pin Inserts

Anatomy of the socket remains unchanged, but now constraints allow for reuse; spread the high cost of the socket



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Modular Sockets at BiTS

BiTS 2009

Modular Design

Flexible Mold Tools

Fast Delivery

Anatomy of the socket remains unchanged, but now constraints allow for reuse; spread the high cost of the socket

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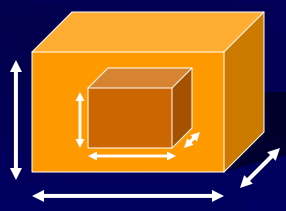
Flexible Socket Designs

More Options

Modular Socket design – same overall anatomy (pins/insulator & force mechanism)



Spread cost over multiple applications

Still buying a socket

Constraints include pin inserts, but is still bound by the idea of an X,Y,Z socket solution

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The Problem

Product Focus vs Program Focus

Socket Definition (BiTS 2000 to 2009):
Socket designs are focused on optimizing for a specific application rather than optimizing for a group of applications

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The Solution

Design Components Not Sockets

1	2	3
2	3	1
3	1	2

BiTS 2000

1	2	3	4	5	6	7	8	9
2	1	4	5	3	7	6	9	8
3	4	5	1	2	8	9	6	7
4	6	1	2	8	9	5	7	3
5	9	6	3	7	2	8	4	1
6	7	2	8	9	1	3	5	4
7	5	8	9	4	3	1	2	6
8	3	9	7	6	4	2	1	5
9	8	7	6	1	5	4	3	2

BiTS 2006

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

BiTS 2010

Sockets Cost Reduction Modular Sockets Decoupled Sockets

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Sudoku & Sockets...?

It's a design concept

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

Decouple components into stand alone units or grouped component building blocks

Look for ways to link universal components across many projects

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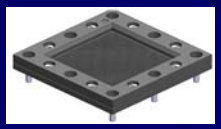
Decoupled Components

System of Independent Building Blocks

The Contact:
Stand-alone design
Functions independently from insulator
High Performance & Low Cost

The Insulator:
Contact housing only
Simple...easy to make & adapt
Cost effective



The Force Mechanism:
Simple independent design
Capable of multiple configurations
High clamping force with low actuation force

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Manage the Blocks

Use what you need...build what you want

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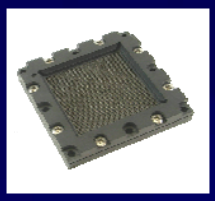
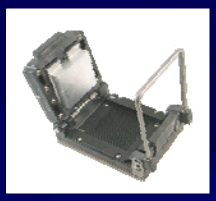
Flexible Business Design

Redesign the Value Delivery System





Socket User:

Actively participate in the design build up

Accept that this may not be optimal for every individual application

Understand the economies gained over multiple applications

Socket Maker:

Need to rethink design, supply chain, manufacturing, and sales

Get comfortable being a component supplier to other socket makers

Develop skills to build sockets with other socket maker's components

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Summary

This concept:

Changes the way Socket Makers and Socket Users think of their business

Asks - can you afford customized designs?

Creates economy of scale with universal components

Forces you to rethink how you do business today

Thank You

For additional information:

larry@locknest.com

Challenges of Test on Balls at Burn-in

Roland Muwanga, Todd Coons, Bimal Shah
Intel Corporation

Test on balls is not new, Burn-In is not new, so what's the challenge?

2010 BiTS Workshop
March 7 - 10, 2010

Outline

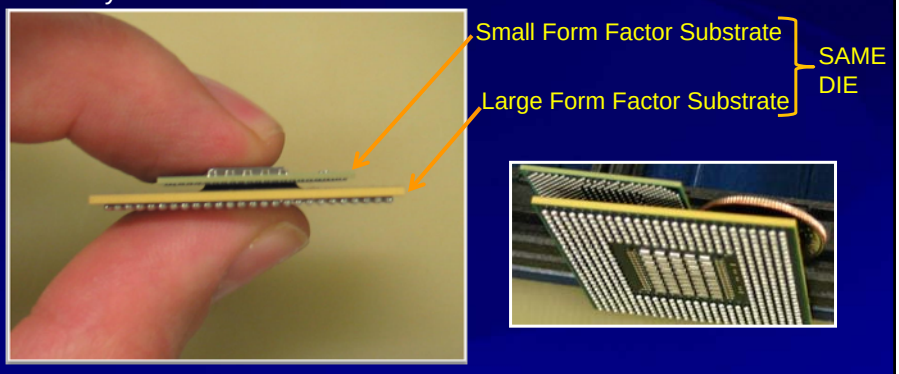
- How are CPU BGA packages changing?
- What are the trends in Ball-Attach processes?
- What's needed at Burn-In to address these changes

CPU Package Trends

- Package size (substrate and BGA) in CPU's has changed dramatically.

Even with the same silicon!

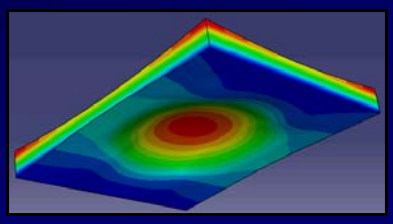
- Fine pitch and thin packages are new for the CPU space where testing criterion are typically more stringent than graphics and memory devices.



3/2010 Challenges of Test on Balls at Burn-in 3

Impact of Package Trends

- Thinner packages and thinner die reduce the allowable pin force
  - High pin force can lead to unwanted package deformation and reliability issues.
  - Package deformation particularly for BGA is a high risk



- **Challenge:** How can we maintain the same contact resistance performance, without impacting the package deformation on packages with decreasing thicknesses?

3/2010 Challenges of Test on Balls at Burn-in 4

Ball-Attach (BA) Process Trends

- Existing trends in semiconductor industry show a move to more eco-friendly ball-attach processes
  - Moving to eco-friendly materials makes the BA process evermore complex
  - These flux/pastes are new for the available pin technology with very little to no data available.
- No-clean ball-attach processes are advantageous as they eliminate process steps in assembly.

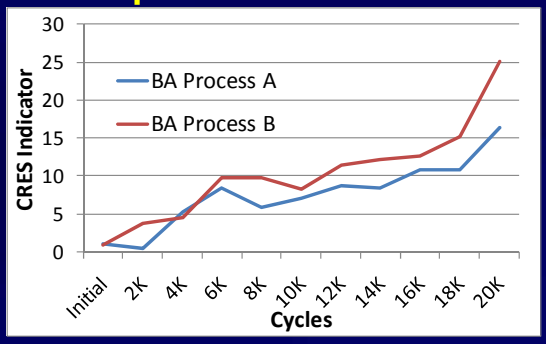
3/2010 Challenges of Test on Balls at Burn-in 5

Impact of BA Process Trends

- Pin contamination can lead to poor signal integrity
  - Inability to track contact resistance leads to yield loss for the producer
  - Retest and/or product tracking makes the automation system more complex
  - Preventative maintenance or increased cleaning frequency negatively impacts throughput time
- Interaction of BA process with socket is unknown
  - Socket should not be a constraint or sensitive to the BA process
  - Substrate backside Keep Out Zones in the ball array may be a future constraint?

3/2010 Challenges of Test on Balls at Burn-in 6

Comparison of BA Processes

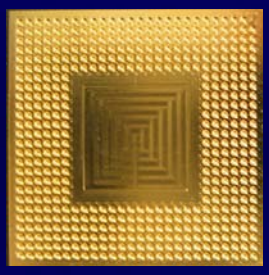


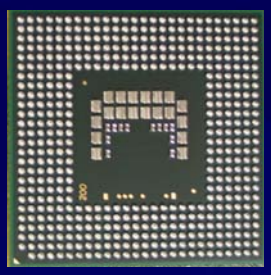
Comparison of CRES using the same pin technology on the same package type

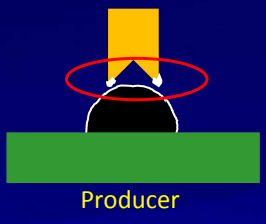
- Two different BA processes can yield significantly different CRES performance
- Trends over time are not necessarily predictable from initial performance

3/2010 Challenges of Test on Balls at Burn-in 7

Pin Testing Methods: Gold DUT versus Solder ball



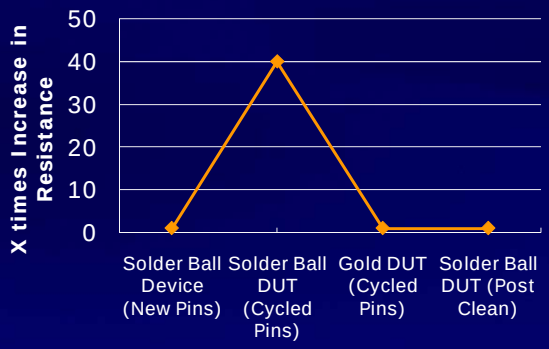




- When testing actual BGA parts, the contact pin tip:
  - Penetrates the flux coating on the balls.
  - Has flux and/or solder contamination which gets transferred to pin over cycles.
- Vickers Hardness is ~20x different.
- SAC305: 14.7
- BECU: 300

3/2010 Challenges of Test on Balls at Burn-in 8

Pin Testing Methods: Pin Data

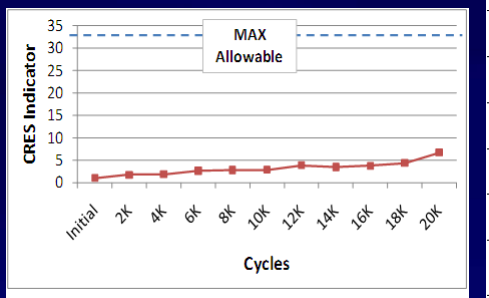


Contact resistance of gold versus solder ball DUTS

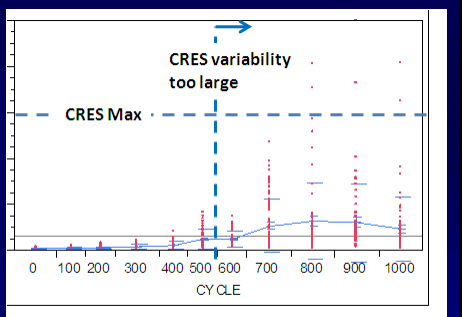
- Gold DUTS have consistent performance when cycle tested to the life of the pins.
- Solder balls DUTs have up to 40x increase in CRES while gold DUTs have good CRES after cycling up to the life of the pins.

3/2010 Challenges of Test on Balls at Burn-in 9

Pin Testing Methods: Single versus Multi-DUTs



CRES based on cycling the same unit



CRES based on cycling fresh units

- Repeatedly cycling the same solder ball DUT can lead to erroneous conclusions of CRES over time.
- **Challenge:** How do you obtain data from a solder ball DUT using fresh units each cycle over the life of the socket?

3/2010 Challenges of Test on Balls at Burn-in 10

Addressing These Trends

- A common new metric is required which encompasses CRES, force and cycles, to compare the different pin types against each other.
- Pin testing methods need to capture the real life test conditions
  - Suppliers should be in tune with the ball-attach trends
  - Pin performance needs to state ball-attach process used
- Innovative pin and socket technology

3/2010 Challenges of Test on Balls at Burn-in 11

Addressing These Trends Cost Effectively

- Test **time** is a key differentiator between BI and other Test steps

	Server	Mobile / Desktop
Struct/Func Test time	X	X
Burn-In time	70X	16X

Example of average times for Structural/Functional test versus BI

- Cost Scaling
  - Socket costs should ideally scale with test time to maintain relative affordability of test step.
  - E.g., with a BI socket at 1/10 the price of a structural/functional test socket, the structural/functional test socket provides1.5X to 10X more production than the BI socket.
- Emerging product trends will challenge this cost scaling!

3/2010 Challenges of Test on Balls at Burn-in 12

Summary

- Packages are getting thinner with finer pitch
- Changes in ball-attach processes are complex
- The interaction of these factors can create new challenges at Test

- ***What's Needed:*** *No-clean contact pins validated on emerging BGA fluxes that are low force and cost effective!*

An Adaptable Test Socket Concept that Meets Both the Test and Burn-In Needs of 21st Century Array Packages

Alexander Barr
3M
Akihiko Furuta, Masahiko Kobayashi, Yoshihisa Kawate
Sumitomo-3M

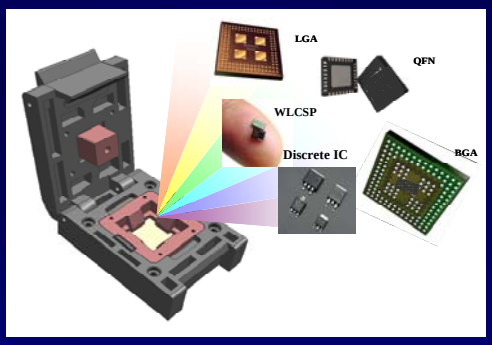
2010 BiTS Workshop
March 7 - 10, 2010

Contents

- Description of the 3M FAST Socket
- Market/Application Space that FAST Socket Addresses
- The 3M FAST Product Line
- Ability to Accommodate Different Ball Patterns and Pitches
- High Speed Testing Issues
- Cartridges to Aid Power and Ground Distribution
- Embedded Capacitance Addressing Power Supply Noise Issues
- Probe Pins
- Flexibility and Economy Improvement Provided by FAST Sockets
- Conclusion

3M FAST Test Socket

Flexible Array Socket for Testing



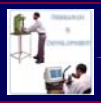
- Can accommodate different:
  - Package thicknesses
  - Package sizes
  - Ball pitches
  - Ball patterns
  - Non-standard or differing ball pitches
  - Probe pins
- Can provide:
  - Pitch conversions
  - Power and/or ground distribution
  - Power noise decoupling
  - SI improvement
  - Flexibility

- Modular cartridge construction
  - Can accept multiple different cartridge designs

3/2010 An Adaptable Test Socket Concept that Meets Both the Test and Burn-In Needs of 21st Century Array Packages 3

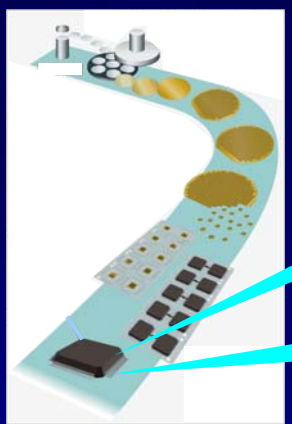
FAST Socket Coverage

R&D center



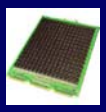
R&D
Function test
Evaluation (HAST, HTOL, ESD etc.)

Factory



Reference source: Nitto Denko

Burn-in
Production Burn-in



Final test
Function test for production

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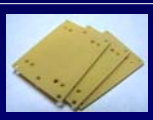
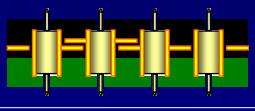
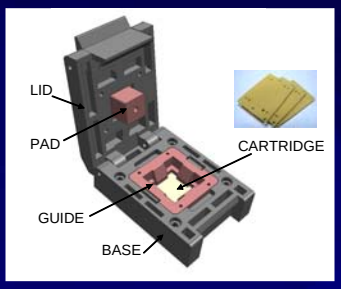
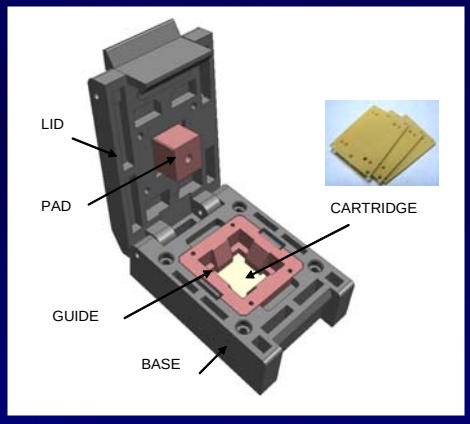
FAST Configurations

	Type-1	Type-2	Type-3
Bodies			
Pins	3M original stamped probe		High performance spring probe
Cartridges	 Free and variable pitch cartridges * Made by PCB process		
	 3M C-Ply to include Embedded Capacitance		



FAST Features

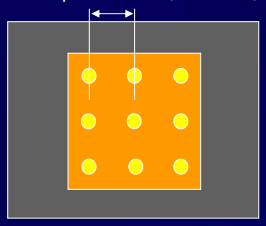


- Standard or economy probe pins
- 0.1 mm to 4.0 mm package thickness
- Standard and variable pitch including staggered patterns down to 0.4 mm pitch
- Compatible with compliant interposer
- Available high speed cartridges
- Probe pin Length: 2.5 mm – 5.7 mm
- Grounding: Yes
- Embedded Capacitance: Yes

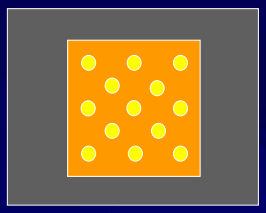
FAST Package Guide & Pin Layout

Non-standard pitch

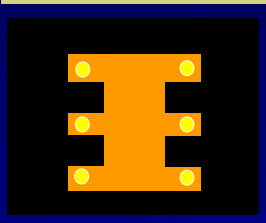
Example: 0.44 mm, 0.55 mm, 0.6 mm pitch



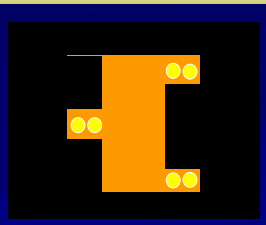
Interstitial



Lead Frame type



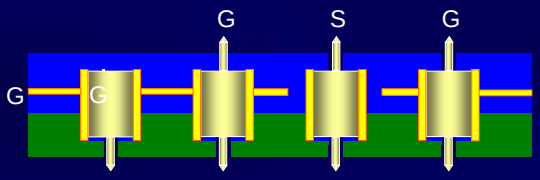
High Current / Kelvin contact

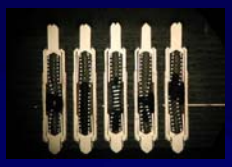


Issues for High Speed Testing

1. Impedance mismatch
   - Multiple connection interfaces create impedance discontinuities resulting in reflections
   - Short probe pins minimize length of impedance discontinuity
   - In Development: Coaxial probe cartridge
     - Will provide match to system impedance and further minimize interface impedance discontinuities
2. Power supply instability
   - Embedded Capacitance Material provides distributed decoupling with improved performance over discrete components
3. Poor grounding
   - Ground layers in cartridges provide low impedance ground distribution
4. Crosstalk
   - Unshielded high speed signals experience crosstalk in tight pitch sockets
   - In Development: Coaxial probe cartridge
     - Coaxial shielding will minimize coupling between neighboring probe pins

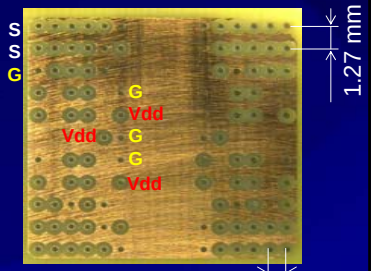
Cartridges to Aid Power and Ground Distribution





Cross section of probe pins

- Low impedance planes increase margin for operating devices because of decreased impedance for supply and return paths
- Minimum supply voltage can be reduced
- Margin of voltage and timing for memory devices will be enhanced resulting in improved SI



Patten of inner layer 0.8 mm

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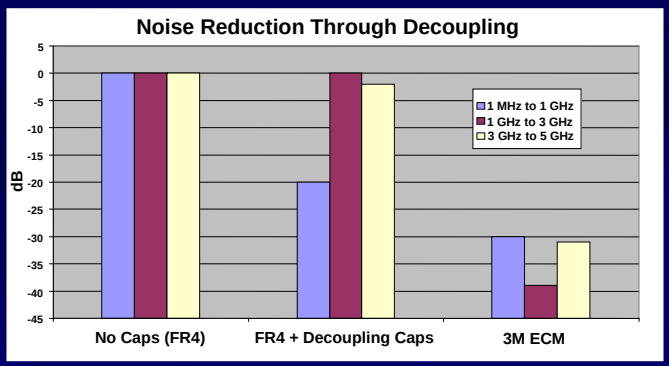
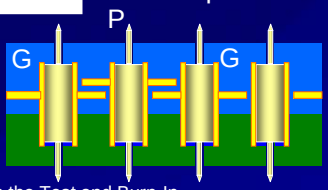
Embedded Capacitance Material (ECM) Addresses Power Supply Noise Issues



- ECM included in test cartridge provides:
  - Integrated decoupling
  - Reduced power distribution impedance over discrete capacitors

Cartridge sample cross section



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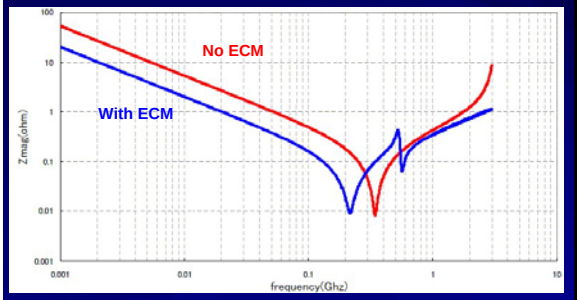
Embedded Capacitance Material (ECM)

- **Lowers impedance of power distribution system**
- **Dampens board resonances**
- **Reduces noise on power plane**
- **Reduces radiated emissions**

Works more effectively at higher frequencies than decoupling caps

ECM Properties

Property	Value (Mass Pro)
Capacitance/area, nF/in²	6.4
Dielectric constant	16
Dielectric thickness, µm	14
Dielectric material	epoxy-filler
Dielectric strength, V/mil	3300
Breakdown voltage, V	>100
Dielectric loss @ 1 GHz	0.03
Freq., Volt., Temp.	meets X7R
Copper thickness, µm	35
Flammability rating	94V-0



Source Japanese customer

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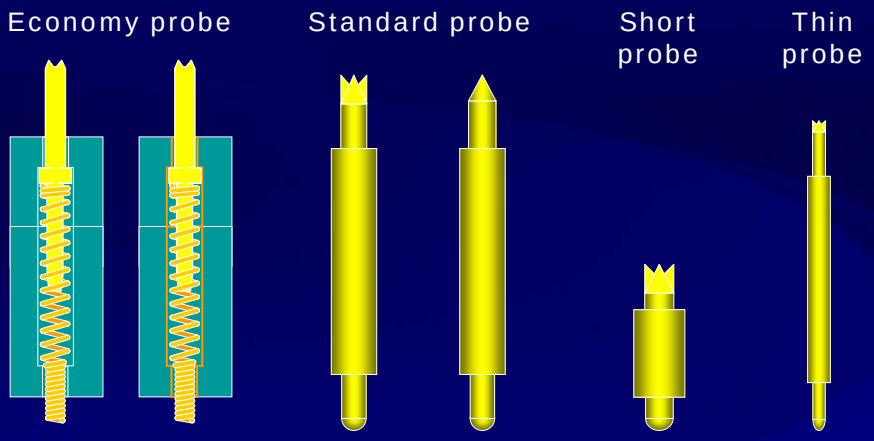
FAST Probe Pin Options



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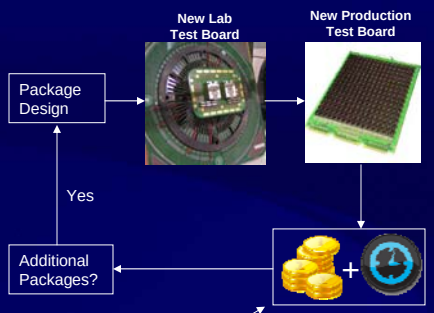
Traditional Testing Approach

Old Paradigm:

- Lab Testing
  - Test boards must be designed for every new package design AND unique singular test fixturing is developed for use only in lab environment
  - Time and expense for generating new test boards with each succeeding design are considerable
- Production Testing
  - Production testing requires test scheme to be re-considered a second time.
  - Full testing, as performed in the lab is typically not available in production

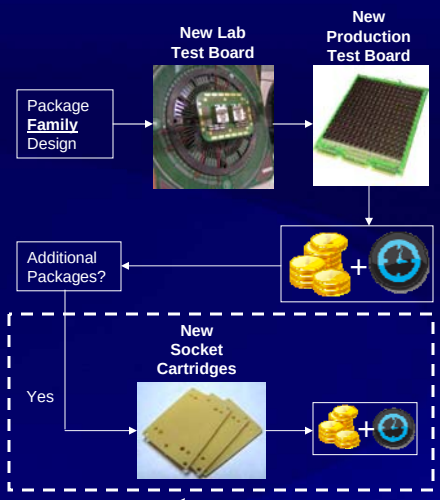


Large Penalty Incurred for Each Package!

Flexibility and Economy Provided by FAST

New Paradigm:

- Lab Testing
  - Test board providing broad functionality is designed once and utilized for Lab testing of a family of packages
  - New socket cartridges are fabricated to accommodate each package iteration within a family at roughly 10% of the cost of generating new test boards
- Production Testing
  - Production testing can leverage subset of Lab testing and board design
  - More accurate and reliable production evaluation is possible
  - Production test boards may be re-used by leveraging new cartridges for new package designs



Small, Incremental Cost!

Conclusion

- The FAST socket is a new modular test and burn-in socket that is designed to meet the cost and flexibility needs of 21st century array packages
- FAST can accommodate different:
  - Package thicknesses
  - Package sizes
  - Ball pitches
  - Ball patterns
  - Non-standard or differing ball pitches

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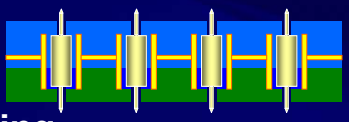
Conclusion

- FAST is adaptable to many different needs including, but not limited to:
  - Pitch conversions
  - Power and/or ground distribution
  - Power noise decoupling
  - SI improvement



Coming: Coaxial Cartridge

- FAST is upgradable minimizing socketing investments as well as providing flexibility that can help reduce time-to-market

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