FIFTEENTH ANNUAL BiTS 2014
Burn-in & Test Strategies Workshop

Session 2

Monday 3/10/14 3:30pm

DOING THE HEAVY LIFTING

Within burn-in and test strategies the heavy lifting that falls to the technologies within test systems is this session's focus. The first paper outlines the issues related to Kelvin contacting for wafer-scale test and presents a solution to these obstacles. The second paper discusses a temperature study of high power switching regulators with thermal shutdown to develop an accurate method of determining junction temperature rise. The final paper introduces using MEMS in place of traditional electro-mechanical technologies.

This Paper

Kelvin Contactors for Wafer-Level Test
Jim Brandes—Multitest - LTXC

Temperature Characterization of High Power Switching Regulators
Paolo F. Rodriguez—Analog Devices, Inc.

LIGA Precision Microfabrication for Electromechanical Applications
Frank Schonig—Innovative Micro Design

Kelvin Contactors for Wafer-Level Test

Jim Brandes
Multitest - LTXC

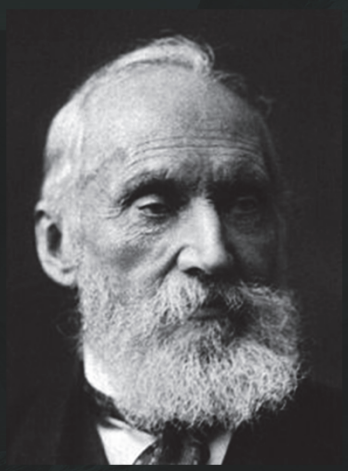
2014 BiTS Workshop
March 9 - 12, 2014

Contents

- Kelvin History and Contactor Examples
- Existing Kelvin product
- Need for Kelvin Spring Probes at WL
- New (finer-pitch) Kelvin product
- Beta Sites
  - Products, timelines
  - Results
- Summary

Kelvin Contact Over 150 Years Old

- Created by William Thompson (Lord Kelvin)
- Also calculated absolute zero
  - Kelvin temperature scale named for him



Industry Standard

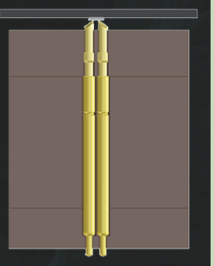
- Kelvin is recognized as the best way to perform R_C-sensitive measurements
- Without a Kelvin connection:
  - Yields suffer
  - Probes require frequent cleaning
  - Probes require frequent replacement

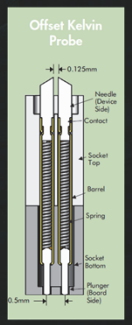
Kelvin is a Mechanical Challenge

- Electrical contact points are small
- Landing a single probe tip is a challenge
- Landing two doubles the challenge
  - Especially in area arrays (BGAs, e.g.)
- Challenge increases as pitches shrink

Many Kelvin Solutions Available

- Efforts made for years to implement Kelvin contacts
- Some have been more successful than others





0.4 mm pitch Kelvin

- Introduced in 2008 - Very successful
  - Hundreds of designs
  - Thousands of contactors
  - Millions of probes
- Main limitation has been pitch
  - Capable of 0.4 mm pitch in-line
  - Capable of full arrays at 0.65 mm pitch
  - Capable of partial arrays at 0.5 mm pitch
  - Capable of partial arrays (peripheral) at 0.4 mm pitch

Need for Kelvin at WL test

- Wafer-Level test has always been an important application for Kelvin
  - Many devices include power management
- Mainline pitch has been 0.4 mm
  - 0.4 mm probe used despite array limitations at 0.4

Contactor for WL test using 0.4 mm pitch probe

Spring Probes for WL Test

- Spring probes good choice for WL test
  - WL test is final test
  - More capability required than wafer probe

Technology	Pogo™ Probe	Spring Probe	Spring Probe	Membrane	Vertical 1
Type	CSP050	0.4 Kelvin	0.3 Kelvin		
Inductance	1.22 nH	1.1 nH	1.8 nH	0.2 nH**	N/A
DC Current	1.7 A	1.8 A	1.5 A	200 mA***	0.5 A
Resistance	100 mΩ typ.	75 mΩ typ.	100 mΩ typ.	< 200 mΩ	< 2 Ω
Bandwidth	5.7 GHz	16 GHz	17 GHz	20 - 33 GHz	1.3 GHz

* In Development ** Tip Only *** On Solder

Membrane and Vertical Probe specifications from internet

Spring Probes for WL Test

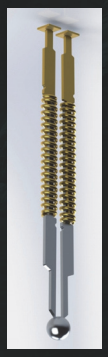
- Prober integration raises some questions
- Contactors are not as coplanar as traditional technologies, but have more compliance
- Contactors typically require more overdrive
- Different cleaning media required
  - Compliant adhesive/abrasive
- New alignment algorithms might be required

First Attempt at 0.3 mm probe Failed

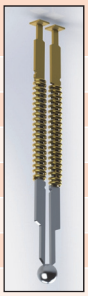
- First Attempt at finer pitch simple shrink of 0.4 mm Kelvin probe
- QuadTech architecture results in geometries that are too fragile
- Development shelved for several years

More-Recent Release of 0.3 mm probe

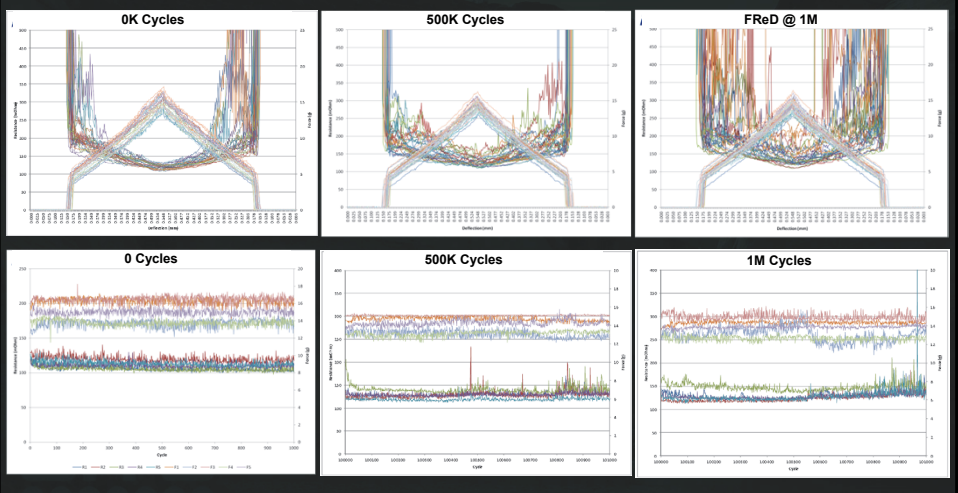
- Development restarted in 2012
- Different approach taken
- Internal contact simple flat-on-flat
- Latching mechanism is different
- A patent has been applied for, based on the latch feature



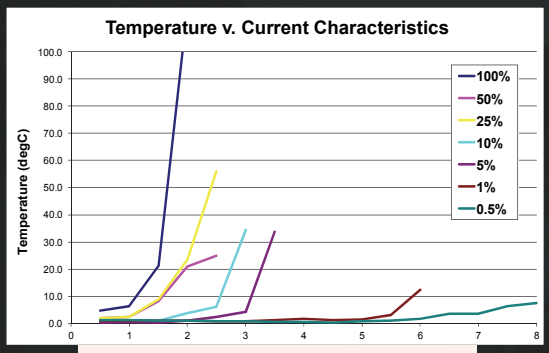
0.3 mm Probe Basic Specifications

0.3 mm Kelvin Probe Specifications	
Conductance @ 20° C rise	1.5 A
Maximum Resistance (New Probe)	150 mΩ
Bandwidth @ -1dB (Dual-Probe, GSG)	17 GHz
Inductance (Loop, Dual-Probe, GSG)	1.01 nH
 Tip Options	KJ Now DJ, BJ Later
Minimum Kelvin Tip Spacing	83 µm
Test Height	3.46 mm
Total Compliance	552 µm
DUT-Side Compliance	412 µm
Force at test height	15 g
Material	H.P. Alloy
Plating (Board Side Only)	Hard Gold

0.3 mm Probe Characterization: Life Test

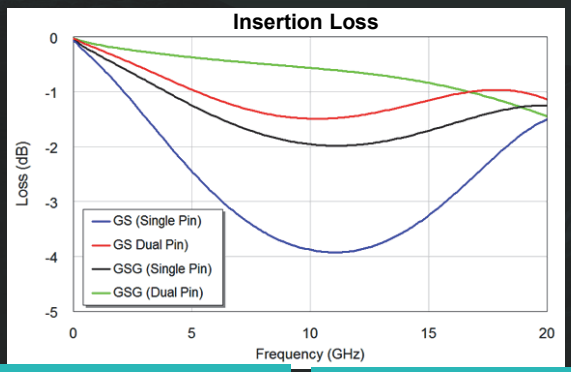


0.3 mm Probe Characterization: High Current Test



20° C Temperature Rise	1.5 A
40° C Temperature Rise	1.6 A
60° C Temperature Rise	1.7 A
1% duty cycle	5.0 A

0.3 mm Probe Characterization: RF Simulation

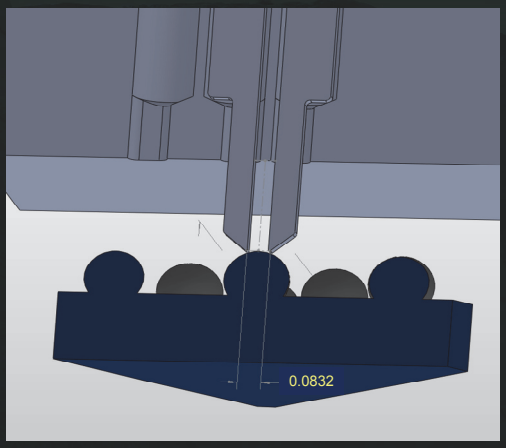


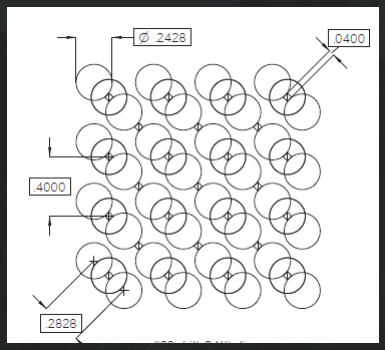
-1dB Bandwidth	
Single-Probe GS	2.1 GHz
Dual-Probe GS	5.2 GHz
Single-Probe GSG	3.9 GHz
Dual-Probe GSG	16.7 GHz

Loop Inductance	
Single Probe	1.77 nH
Dual Probe	1.01 nH

Inductance values are GSG
All values at 0.3 mm pitch

Board Fabrication Challenging

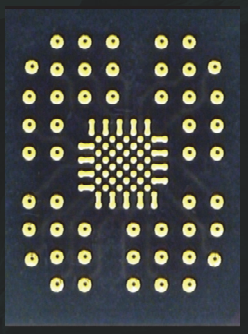




Equally distributing the probes to make contact to a 0.4 mm pitch device results in a probe pitch of 283 µm and a probe tip spacing of 83 µm

Board Fabrication Challenging

- Space Transformer Board
  - May be used for full Kelvin @ 0.4 mm
  - Resulting Pitch: 283 µm
- Full Performance Board
  - Full Kelvin may be possible @ 0.4 mm
  - Depending on probe and site count
- Only a few shops are Capable

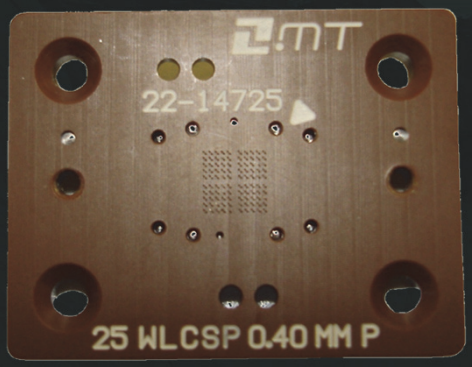


Space Transformer Board

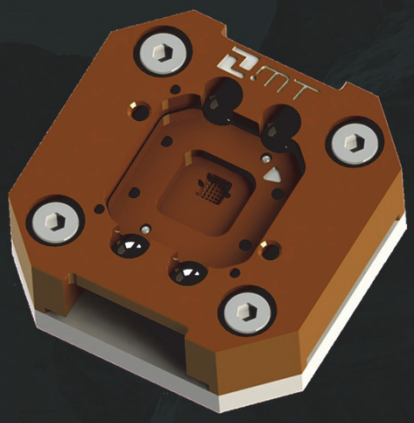
Beta Site History #1

- First beta-site contactors shipped Feb 2013
  - 25-ball device
  - WL test and manual test contactors
  - Only used for engineering work
- Each contactor has only a few thousand uses
  - Insufficient to conclude beta site
- User excited – has acquired several more
  - Three quad-site (25-ball device)
  - One quad-site (12-ball device)

First Beta-Site Contactors



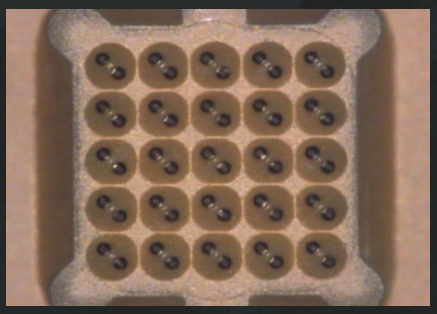
Quad-site HVP contactor



Drawing of single-site hand-test contactor

Contactor for Singulated Devices

- Probe designed to support a FAP
- Necessary for singulated devices
- Wafer-level or other packaging

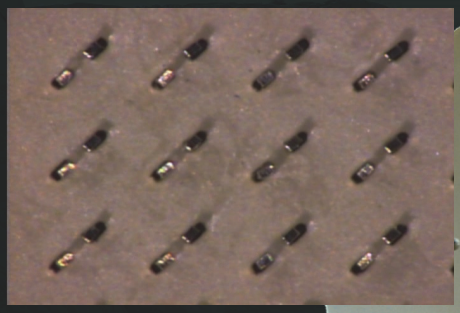


DUT pocket of contactor for singulated 25 BGA

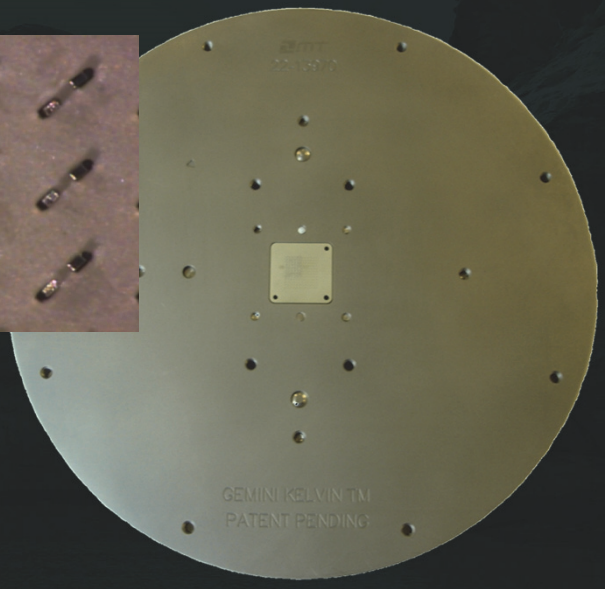
Beta Site History #2

- Second beta-site contactor shipped March 2013
  - "Universal" WL contactor – 0.5 mm pitch
  - 12 X 12 array, partially populated
- It took a visit in July to get them to start using
- 150 k touchdowns
  - Life and yield far exceeded incumbent
  - Insufficient to conclude beta site
- User excited enough to acquire more

Second Beta-Site Contactor



Close-up of probes in the populated area of the "universal" contactor



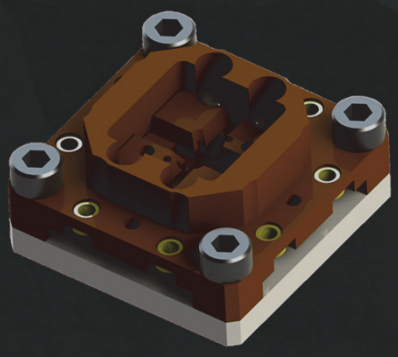
Beta Site History #2

- Additional Shipments:
  - One "universal" (12 X 12), 0.4 mm pitch
    - August 2013
  - Second universal 0.5 mm pitch
    - August 2013
  - Three quad-site HVP contactors, 46-ball
    - December 2013
  - Spare probes
- Still not enough high-volume production data to conclude beta site

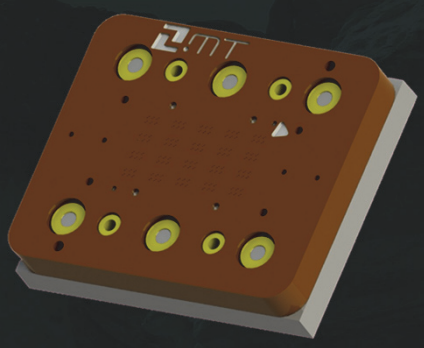
Beta Site History #3

- After browbeating, 0.3 mm pitch probe offered to a third user, on an evaluation basis
- Two contactors for singulated devices
  - 32-ball device – July 2013
- Two 20-site HVP contactors
  - 6-ball device – October 2013
- Five quad-site HVP contactors
  - 12-ball device – February 2014
- Spare probes
- Still not enough high-volume production data

Third (Evaluation-Site) Contactors



Single-Site, 32-ball device
For rotary handler



Twenty-site, six-ball device
For HVP of WL devices

Summary

- Twelve months later . . .
- With 26 contactors in the field . . .
- Of twelve separate designs . . .
- The beta site stage is *still* incomplete
- (That's the way it goes sometimes)