PLOT showcase:

Board Level Reliability Test System development

Mark Gortemaker

November 25, 2015

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- MASER Company profile
- Semiconductor & System reliability
- Board Level Reliability (BLR) test capability overview
- New system for BLR drop test
- Summary

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MASER Company profile

- MASER Engineering is an Independent Service Provider founded in 1993 and privately held by Hans Kemper and Kees Revenberg
- Almost 25 years experience in test and diagnostics of Semiconductors, Electronic components and electronic systems
- Reliability Test and Diagnostic services are offered to a wide range of customers that are active as Fabless Semiconductor or Integrated Device Manufacturers, automotive electronics supplier or in Aerospace and Space applications.
- Main office & laboratory Capitool 56, Enschede, The Netherlands
- Staff 43 employees (37 FTE), half with PhD / MSc / BSc degree
- 4 Sales representatives covering Western Europe and Israel
- Branch related memberships

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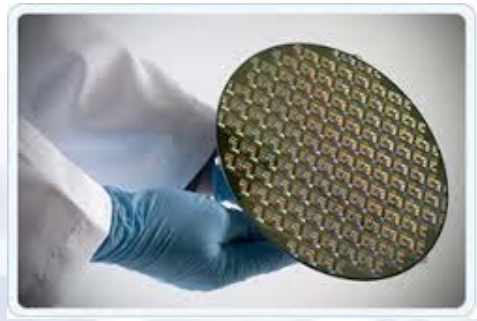
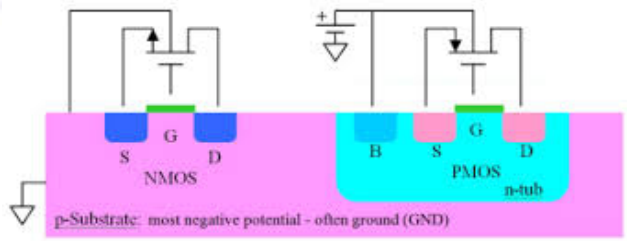
Semiconductor reliability (Wafer)

- **Industry accepted specifications**
  - JEDEC JESD47G
  - AEC-Q100
  - MIL-STD-883



- **Models**
  - Arhenius: accelerated life time testing of silicon
  - Coffin Manson: TC testing of component and board level solderjoint

- **Wafer FAB process qualification tests**
  - Hot Carrier Injection (HCI)
  - ElectroMigration (EM)
  - Negative bias Temperature Instability (NBTI)
  - Time Dependent Dielectric Breakdown (TDDB)



Semiconductor reliability (product)

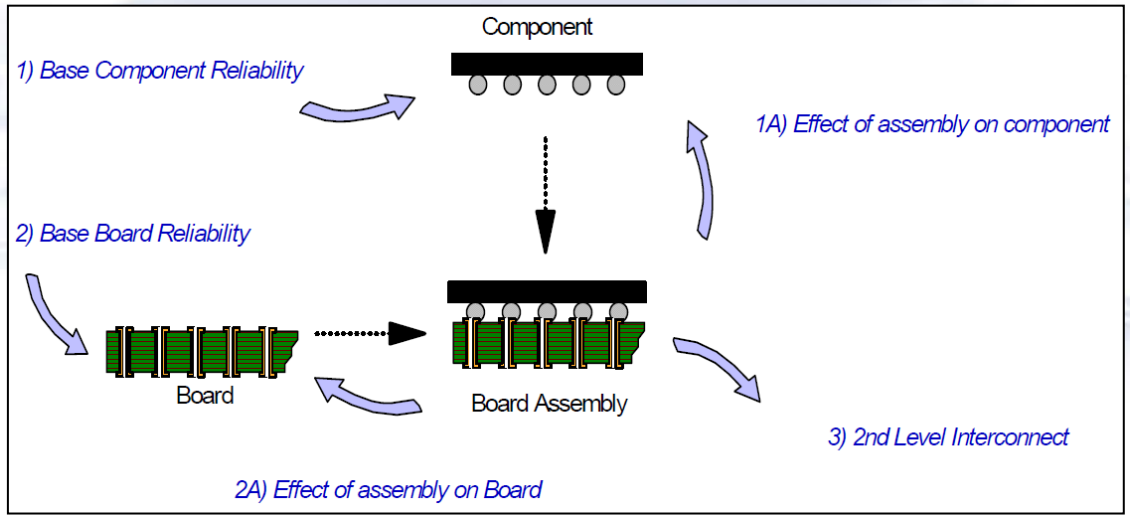
- **Product qualification**
  - 3x77 High Temperature Operating Life (HTOL) test @ Tj=150C for 1000 hrs (2000/3000 hrs)
  - ESD (HBM/CDM) and Latch UP test
- **Package qualification**
  - MSL preconditioning prior to TC/HAST/UHST/THB
  - 3x25/3x77 Temperature Cycling (TC) test -65/+150C for 500 cycles
  - 3x25/3x77 Highly Accelerated Stress Test (HAST) test biased @ 110C/85%RH for 264 hrs (THB)
  - 3x25/3x77 Unbiased Highly Accelerated Stress Test (UHST) test unbiased @ 110C/85%RH for 264 hrs
  - 3x25/3x77 High Temperature Storage Life (HTS) test @+150C for 1000 hrs
  - 1x45 Power Temperature Cycling (PTC) test -40/+125C for 1000 cycles biased 5min on/5 min off
- **Mechanical**
  - Package DROP, shock, vibration and constant acceleration
  - Solderability, wirepull and ball shear
  - Fine and Gross leak

Semiconductor reliability (2nd level)

- **JEP150**
  - Stress-Test-Driven Qualification of and Failure Mechanisms Associated with Assembled Solid State Surface-Mount Components (May 2005)

- **Board Level Reliability**
  - BLR TC test to characterise solderjoint reliability with daisy chain devices -40/+125C for 1000 cycles
  - BLR Drop test to characterise solderjoint reliability with daisy chain devices for 1000 drops
  - BLR Bending test to characterise solderjoint reliability with daisy chain devices for 250K bends
  - Results plotted in weibull plot

- **Summary**
  - Process qualification (WLR)
  - Product qualification
  - Board level reliability (BLR)



System level tests (HALT / IPC)

- **HALT test**
  - Used as design tool
  - Stress the first design out of spec to find the weak spots
  - Use temperature step stress (high/low), fast temperature cycling (5x), random vibration step stress and combined temperature cycling and vibration test.
  - Goal: validate the robustness of the (first) design
  - Improvements can be implemented during test e.g. new components or changes.
  - With the found limits implement HASS (at the production site, since HASS is an inline screening test)

- **IPC-A-610 inspection**
  - Initial quality of PCBA (design, PCB manufacturing and assembly process)

IPC-A-610 CERTIFIED IPC TRAINER
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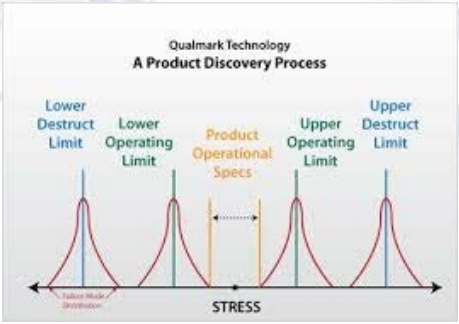

System level tests (ENV / Mech)

- **Environmental tests (validation)**
  - IEC and/or MIL-STD-810 specification
  - Operational test (high and low temp with datasheet min/max)
  - Temperature cycling
  - Moisture Resitance test
  - (Cyclic) Damp heat

- **Mechanical tests**
  - IEC and/or MIL-STD-810 specification
  - Random and sinusodial vibration tests
  - Bump and shock tests (high and low temp)

- **Other tests focussed on the housing**
  - IEC and/or MIL-STD-810 specification
  - Gas corrosion, SALT mist, Solar radiation, Dust and Water Ingression tests (IP)

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BLR test capability overview

- **Board Level Reliability (BLR) tests are intended for characterisation of solder joints for package concepts. For the drop, bending, TC and vibration test daisy chain devices are used in test with glitch / event detection. A weibull plot is used for reporting the results.**

- **Board Level Reliability - Drop test**
  - JEDEC JESD22-B111
    - 1500g, half sine, 0.5ms, drop until fail or 1000 drop cycles
  - Customer spec
    - 1500g, half sine, 0.5ms, drop until fail or 1000 drop cycles (tighter specification and repeatability)

- **Board Level Reliability - Bending test**
  - JEDEC JESD22-B113 (Dynamic) up to 200.000 cycles
    - 200.000 cycles , 1-3 Hz, 4 mm deflection
  - IPC9702 and IEC 60068-2-21 (Static)

- **Board Level Reliability - Temperature Cycling test**
  - JEDEC JESD22-A104
    - -40/+125°C, 1 cycle/hour and ramp-rate: 10-11 K/min (upto 15K/min)

- **Board Level Reliability - Vibration test**
  - Frequency range: DC – 4000Hz
  - Sine acceleration: 100g
  - Sine force: 10.000N/1.000kgf
  - Displacement: 51mm

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Why BLR drop tests

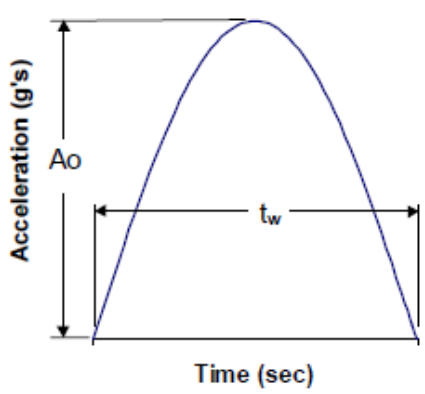
- Assess package solderjoint drop test reliability performance
- Simulate drop of handheld applications e.g. mobile phone
- Industry accepted a standard to compare different devices and improvements
- Actual drop test performance in application can be different
- Practical test: Tumble test

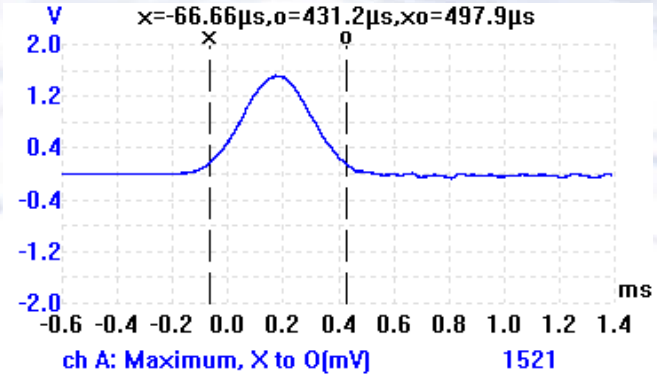
Why new system for drop test

- Special customer requirement could not be met with existing Lansmont system
- Manual glitch detection could result in failures
- Man capacity limitation
- Automated system needed in combination with automated glitch detection
- Shorter system length to focus on BLR tests ~ 1500 g

BLR test specifications

	Special customer	JEDEC
Acceleration:	1500G	1500G
Pulse duration:	0,5ms	0,5ms
Test duration:	1000 drops	1000 drops
Shape:	half-sine pulse	half-sine pulse
Acceleration (tolerance):	± 10%, with Cpk ≥ 1.33	Not specified
Duration (tolerance):	± 10%	Not specified

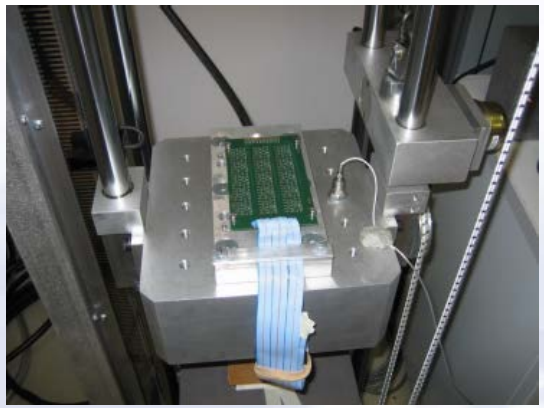




- Conclusion of evaluation: The new MASER Engineering BLR drop tester meets the customer specification

Shock / drop test systems

- **Lansmont M23 Shock testing machine**
  - Supplier : Lansmont M23
  - System height : 2,80 meter
  - Pulse shape : Half sinusoidal; Trapezium shaped
  - Pulse duration : 0.1 ms to 40 ms
  - Maximum g-level : 10.000g (0.1ms)
  - Max. payload : 35 kg
  - Application : general



- **MASER Engineering BLR Drop testing machine**
  - Supplier : MASER in-house development
  - System height : 1,50 meter
  - Pulse shape : Half sinusoidal
  - Pulse duration : 0.1 ms to 11 ms
  - Maximum g-level : 1500g (0.5ms)
  - Max. payload : 5 kg
  - Application : low G level tests (e.g. Board Level Reliability drop tests)

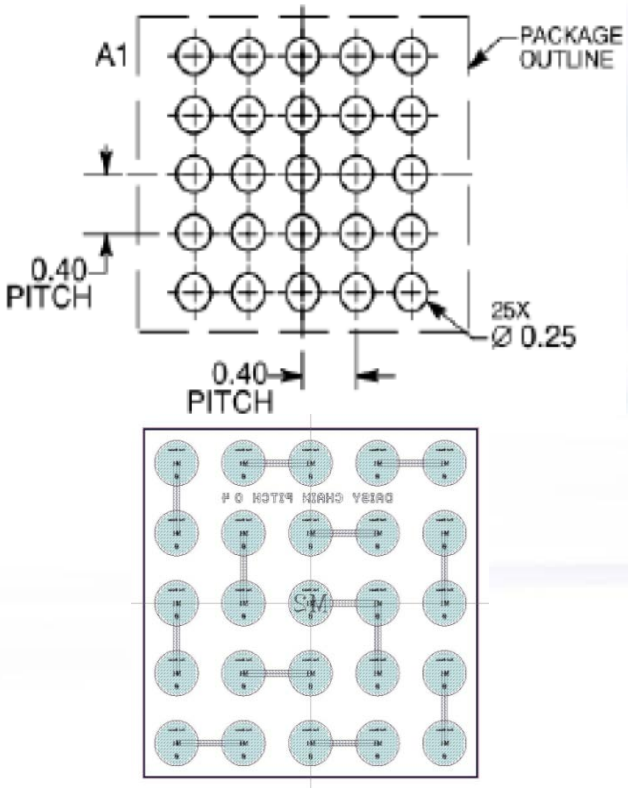
- **Event detector**
  - Supplier : MASER in-house development
  - Number of channels : 16 / 32
  - Event duration : 1µs
  - Option : ability to stop test after first failure detected

BLR drop testing

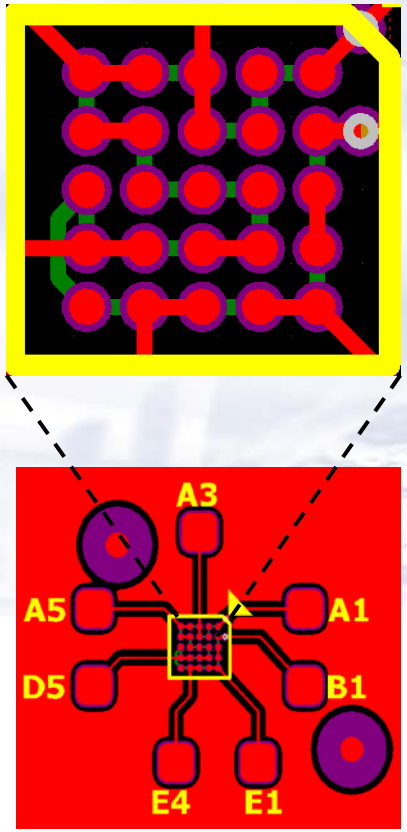
- Typical test using 4 boards
- 15 devices / board = 60 devices
- Design, manufacturing and assembly of PCBA
- Daisy chain devices required (low ohmic)
- BLR drop testing
  - failure: 4 events within 6 drops
  - event: R > 1kOhm , t > 1µs
- Results in weibull plot
- Detailed FA required to assess the weak point

BLR Board design

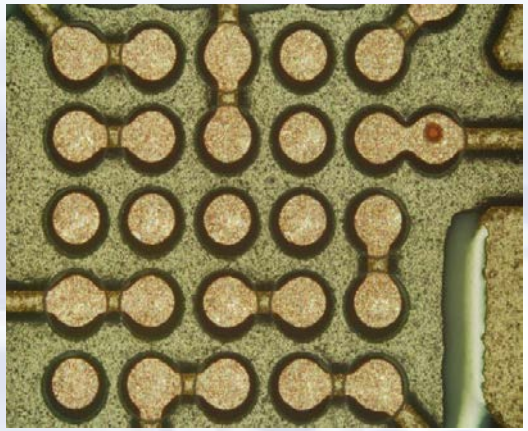
customer input

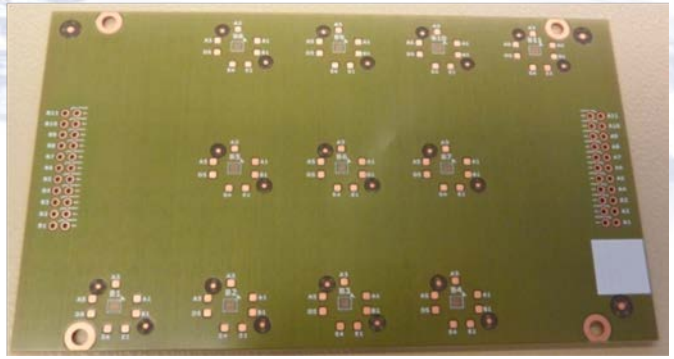


board design

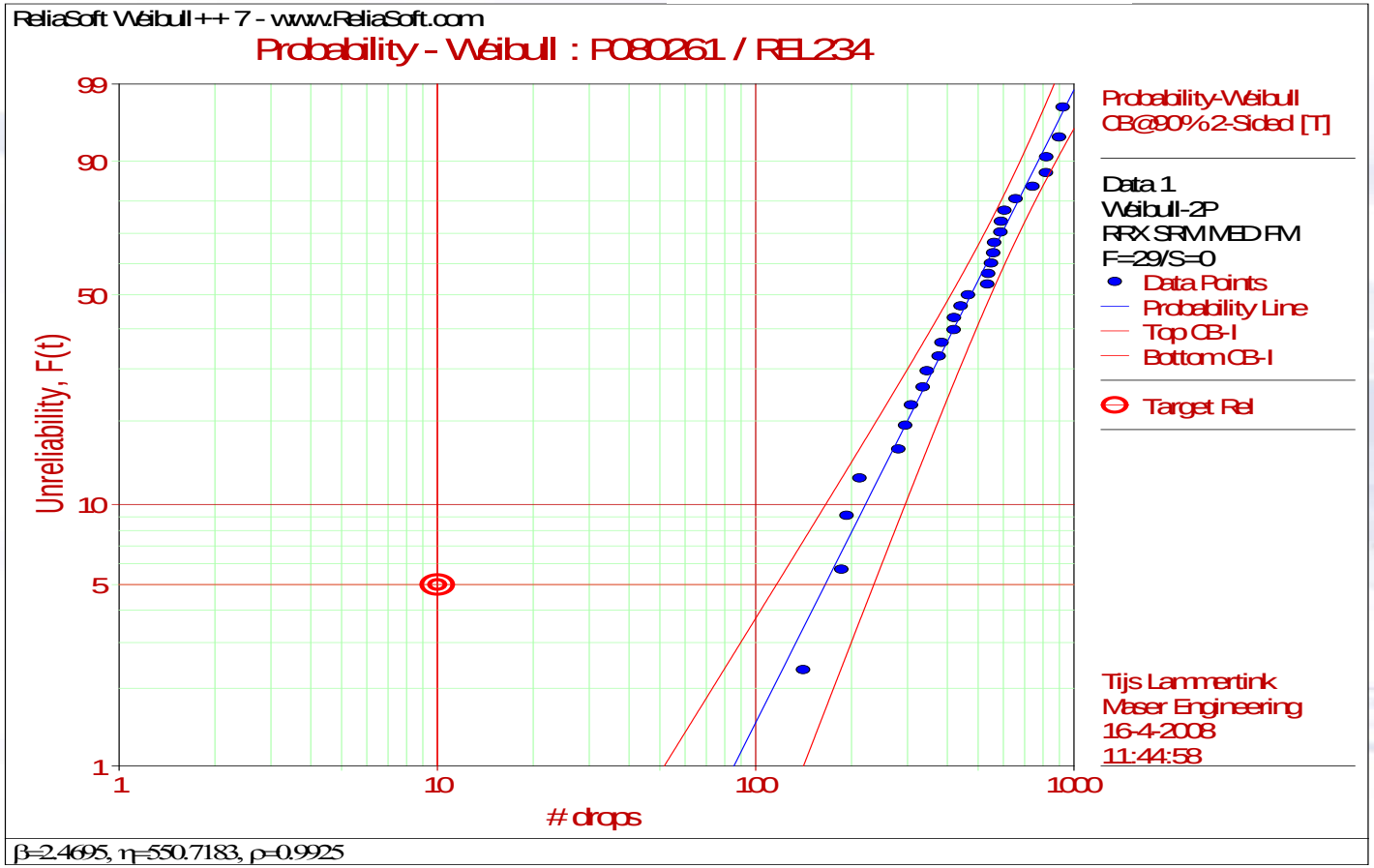


actual board





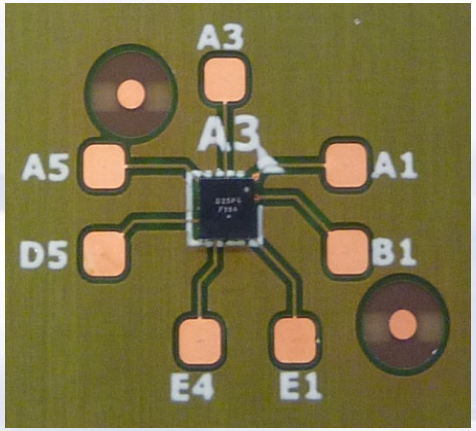
Reporting: Weibull distribution

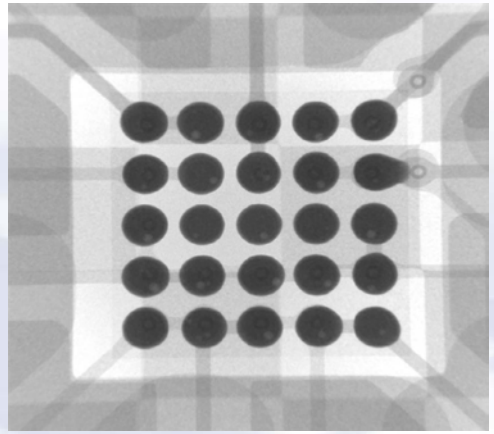


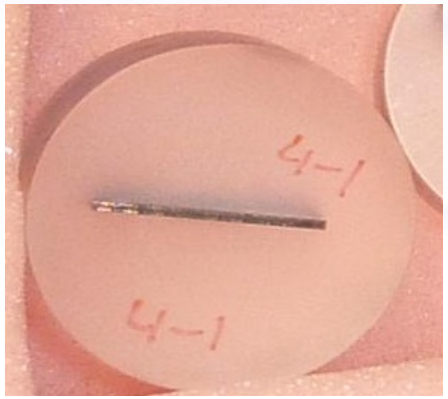
Reported results as Weibull plots

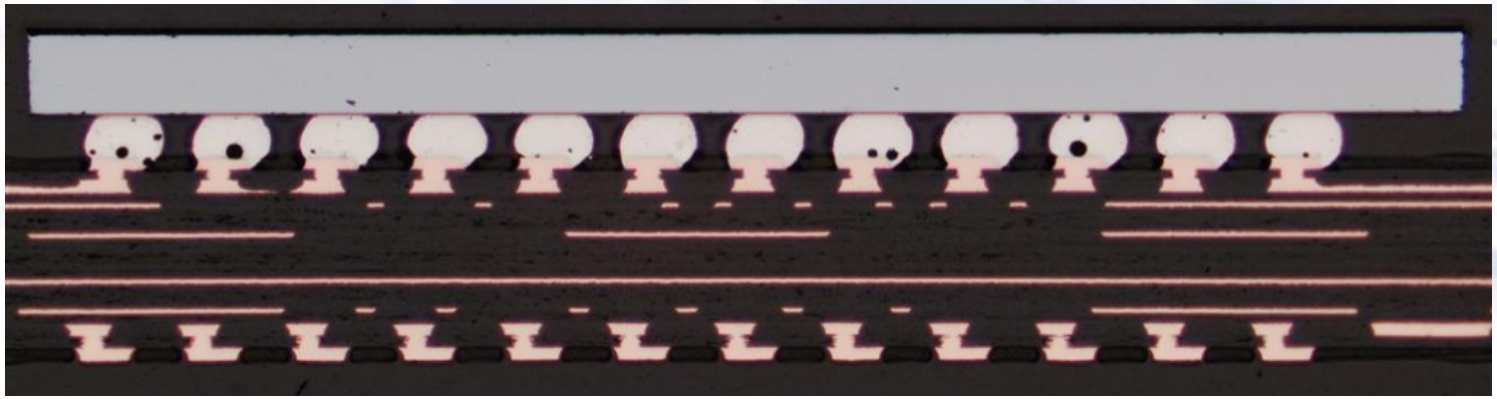
Failure Analysis

- Continuity measurement
- X-ray inspection
- Cross-section row-by-row

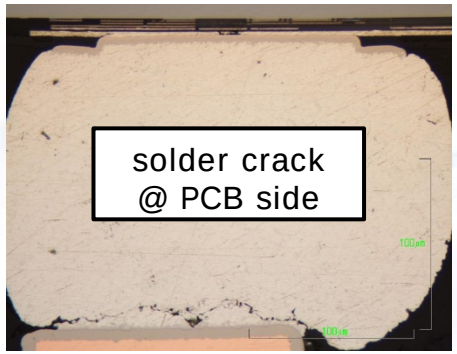


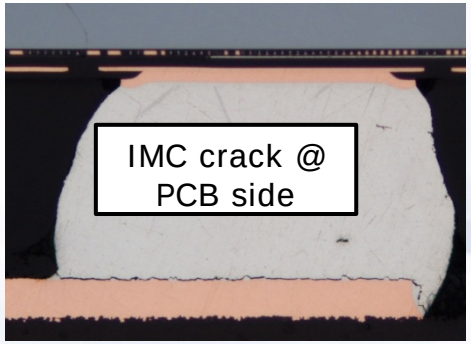


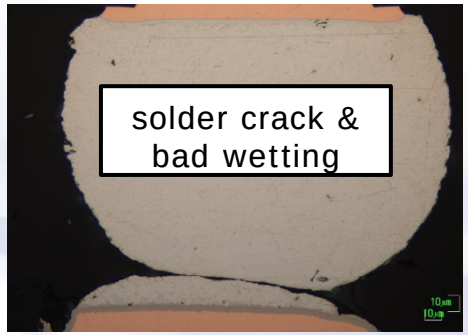


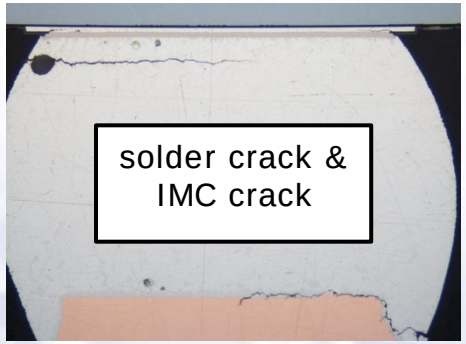


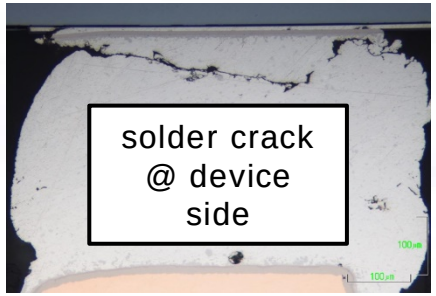
Cross-section failure modes

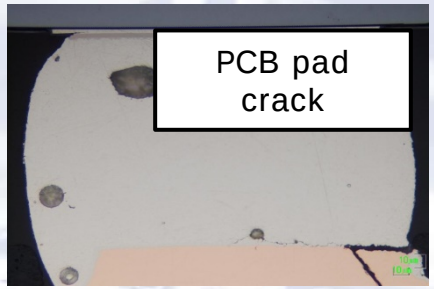


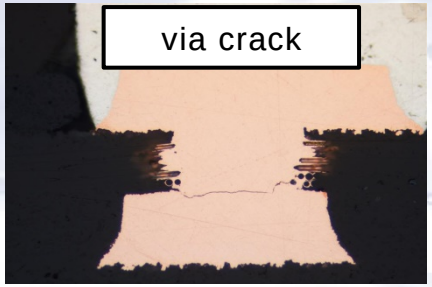


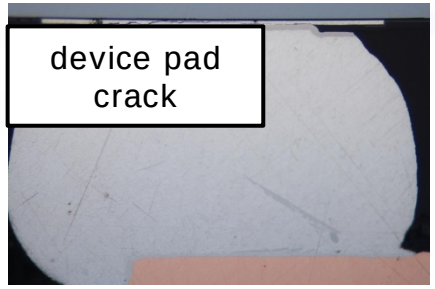


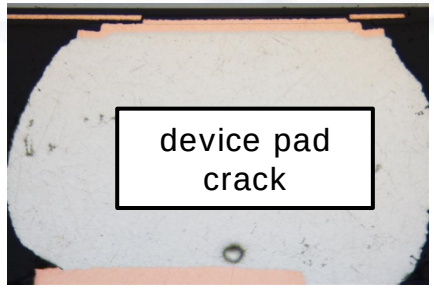


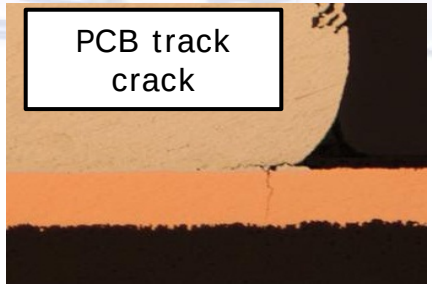




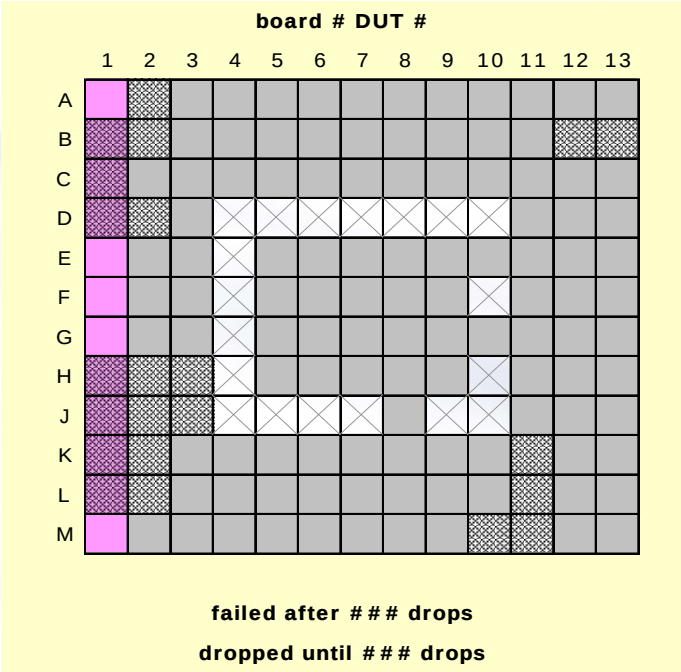


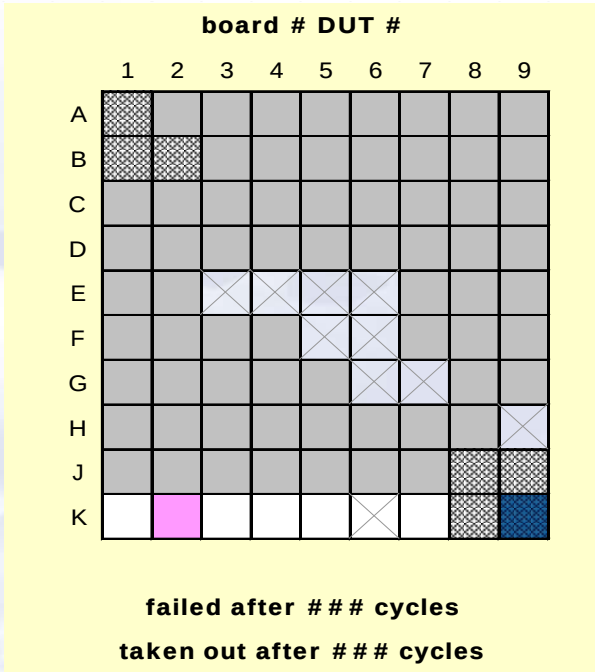


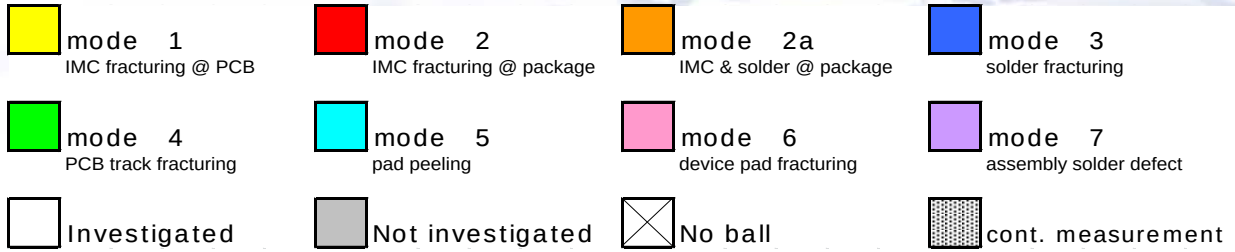




Failure mode distribution





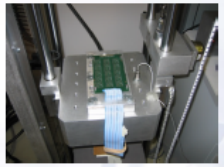


BLR Test Services

MASER ENGINEERING

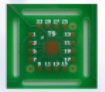
Board Level Reliability (BLR) test services

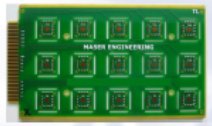
Board Level Reliability (BLR) tests are intended for characterisation of solder joints for package concepts. For the drop, bending, TC and vibration test daisy chain devices are used in test with glitch/event detection. A weibull plot is used for reporting the results



BOARD LEVEL RELIABILITY TESTS:

- Characterisation of package solder-joint reliability using weibull
- Daisy chain devices used for test
- Glitch/event detection and monitoring
- In-house board design capabilities
- Thermal cycling (JEDEC)
- Drop test (JEDEC)
- Dynamic board bending (JEDEC)
- Static (monotonic) board bending
- Vibration test





BLR BOARD DESIGN:

- In-house design capability and know-how
- Project management of board manufacturing and assembly
- Standardized board size for DROP and Bending test: 132x77 mm (JEDEC) 8-layer FR4 boards
- Standardized board size for TC tests 220×127 mm 2-layer FR4 boards (using break away PCB per device for FA)

BLR THERMAL CYCLING:

- 2x Espec TCC-150W
- 1x Espec EGNZ12-7.5cwl
- 1x Espec HC-120
- JEDEC JESD22-A104
- Typical test condition:-40/+125°C, 1 cycle/hour and ramp-rate: 10-11 K/min
- Data acquisition by daisy chain resistance monitoring
- Central Monitoring System (CMS)

BLR test service leaflet 2015-1

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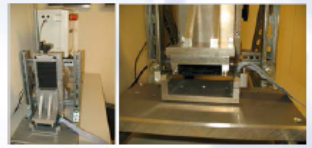
Board Level Reliability (BLR) test services

BLR DROP TEST:

- 1x Lansmont Drop tester
- 1x MASER BLR Drop tester (developed by MASER Engineering)
- Glitch detection by daisy chain resistance monitoring
- Specification:
- JEDEC JESD22-B111, 1500g, half sine, 0.5ms, drop until fail or 1000 drop cycles
- Customer, 1500g, half sine, 1.0ms, drop until fail or 1000 drop cycles



BLR BENDING TEST:

- 1x MASER Bending tester (developed by MASER Engineering)
- Data acquisition by daisy chain resistance monitoring
- Specifications:
- JEDEC JESD22-B113 (Dynamic) up to 200.000 cycles
- IPC9702 (Static)
- IEC 60068-2-21 (Static)

BLR VIBRATION TEST:

- Electro Dynamic Shaker (ETS Solutions M124/GT600M)
- Data acquisition by daisy chain resistance monitoring
- Specification:
- Frequency range: DC – 4000Hz
- Sine acceleration: 100g
- Sine force: 10.000N/1.000kgf
- Displacement: 51mm

For more info please visit www.maser.nl
For inquiries please contact : info@maser.nl or call +31 53 480 26 80

BLR test service leaflet 2015-1

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http://www.masernl.com/files/BLR%20test%20service%20leaflet%202015-1.pdf

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Summary

- **MASER Engineering has almost 25 years experience in the semiconductor and electronic system industry**
- **Our customers operate in the following industries:**
  - Automotive
  - High tech Semiconductor
  - (Aero)Space
  - Medical
  - Industrial
  - Consumer
- **Our laboratory contains a broad range of systems for executing tests e.g. mechanical (shock, drop, bending, vibration) and environmental (temperature, climate, salt mist)**
- **Operate a dedicated tool shop for fast and flexible fixture design support**
- **We can support in advise in defining a test plan (due to our experience with many different customers in different industries)**

Thank you for your attention.

Questions?