PLatform OmgevingsTechnology Reliability Seminar @ E&A 2015

Mechanical Test
a key stressor of wearable electronics

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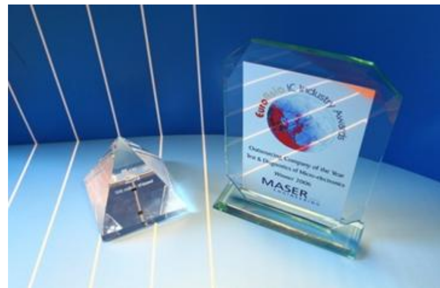
Outline

- **Introduction**
- **Wearable Electronics**
  - Scope and mission profile
  - Physical Failure modes
- **Mechanical Test definition**
  - Classes and Purpose
  - Fixture and Monitoring preparation
  - Vibration exposure
  - Shock impact
  - Bending stress
- **Examples**
- **Summary**

Introduction

- Independent Test & Diagnostics of Microelectronics
- Failure Analysis services for IC’s and electronic components
- Circuit Edit capabilities <28nm CMOS node
- Reliability Test services for full product qualification and ESD/LU tests
- Mechanical Test services with mid-size shaker, bending and shock
- ISO9001 certified and ISO17025 accreditation (RvA L388)
- Founded in 1993, 48 employees (>60% engineering degree)
- 1900m² office & laboratory at Business & Science park Enschede, NL
- 4 representations covering EU and IL



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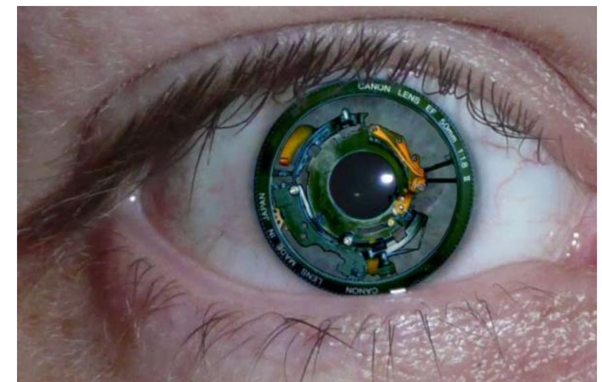
Wearable Electronics

- **Scope and Mission Profile**
  - Wearable electronics by people or things
  - Small electronics, battery powered tools & gadgets
  - No portable or transportable equipment/tools/gadgets
  - Special class of implantable electronics → medical application
  - Leasure, mobile audio/video, Internet of Things
  - Human environment → mild/moderate climat
  - Multiple physical handling at uncontrolled movements



Wearable Electronics

- **Physical Failure Modes**
  - Intrusion of Moisture / Water / Body fluids
  - Drop & Shock
  - Washing / Tumble dryer
  - Wire Pull / Cracks
  - Mechanical stress impact / Mishandling
  - Temperature is not often a stressor
- **Major contribution of defects**
  - Based on mechanical stress impact
- **Mechanical wearout: instant or slow slope**
- **New test techniques to test these stressors**

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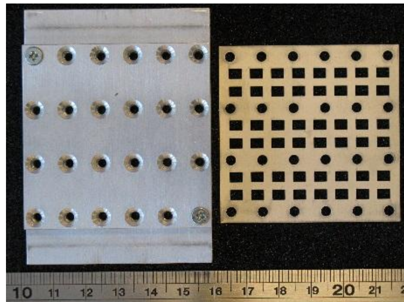
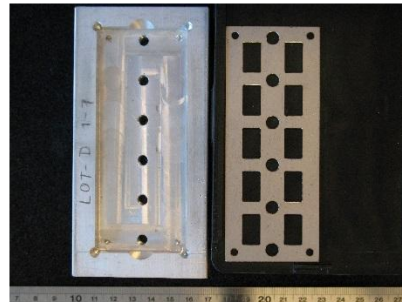
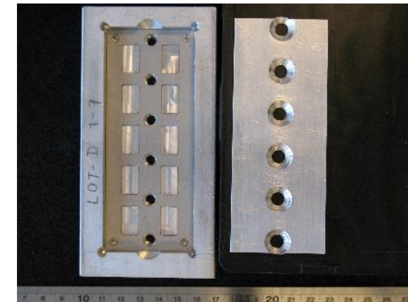
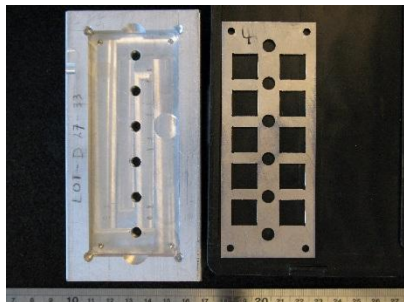
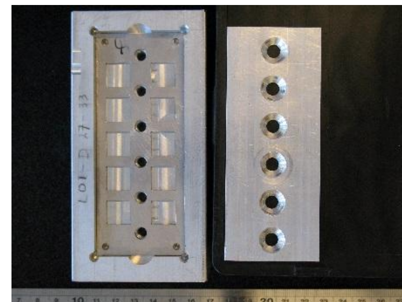
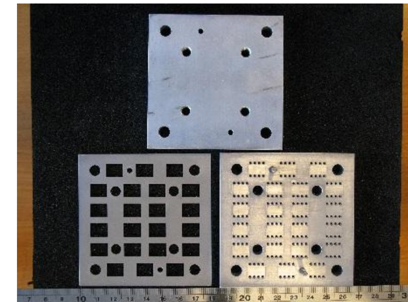
Mechanical Test definition

- **Classes and Purpose**
  - Drop → impact on various floors, side control
  - Free fall → impact on various floors, no side control
  - Tumbling → washing machine and transport
  - Mechanical Shock, half sine → high impact, side control
  - Mechanical Shock, trapezium → longer impact on heavy units
  - Vibration, swept sine → mechanical housing strength
  - Vibration, resonance search → high stress @ resonance
  - Vibration, random spectrum → simulation of real world, 1 axis
  - Mixed mode and Multi axis stress → further simulation
  - 6 DOF random → wide band impact at small components
  - Constant Acceleration → internal mounting strength
  - Bending → (solder) interconnect stress
  - Pull/Push → mechanical strength of wires
  - Shear → lateral strength

MT – Fixturing & Monitoring

- **Fixture preparation**
  - Major impact on successful test
  - Fixturing should not introduce stress
  - Fixturing has to spread stress impact evenly over sample
  - Both Package Outline Drawing and mechanical reference

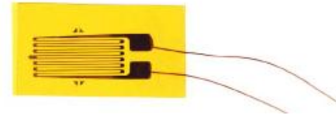







MT – Fixturing & Monitoring

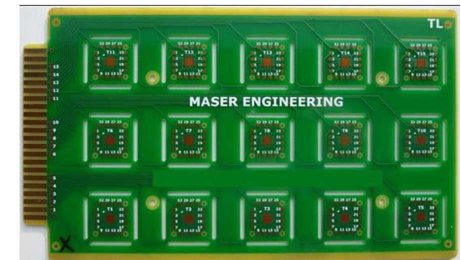
- **Fixtures for Wearable Electronics**
  - Complex outline
  - Rounded objects
  - No fixturing features
  - No definition in standards
  - High impact on results
- **Fixture with clamps**
  - Individual machined
  - Wax based adaption
  - Tape based fixation
- **Fixture w/o clamps**
  - Fixed to rigide part only
  - Glue based fixation

MT – Fixturing & Monitoring

- **Monitoring mechanical stress parameters**
  - Accelerometers, piezo or laser based
  - Strain gauges
  - Load cells

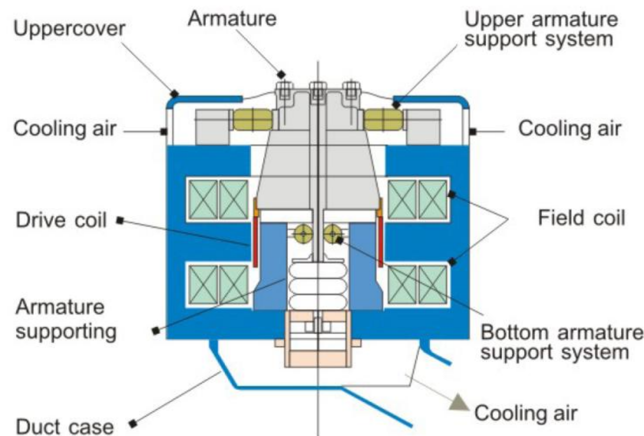


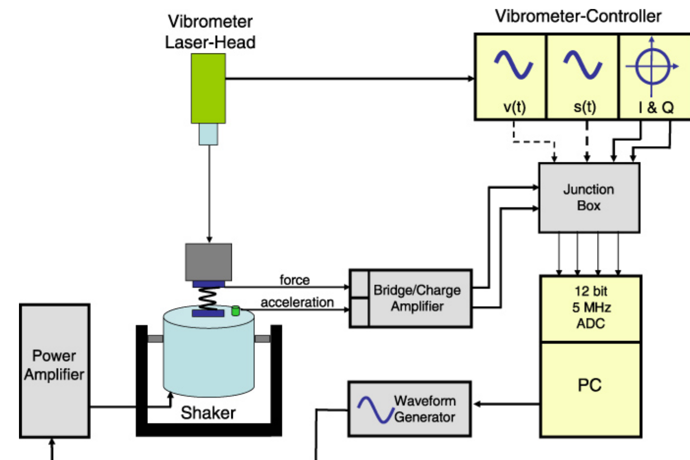
- **Monitoring object behavior**
  - Electrical parametric signal monitoring
  - (High Speed) digital video imaging
  - Stroboscopic or laser interferometer
  - Glitch detection of daisy chained interconnections (BLRT)
  - Time continue monitoring of 10% rise of R @ 10μs
  - Resistance scanner for slow slope tests



MT – Vibration exposure

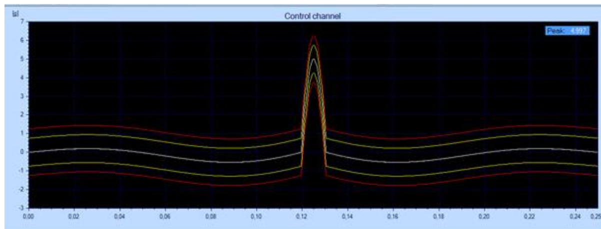
- Single axis movement by Hydraulic Cylinder
  - For extreme high forces → n/a for wearable electronics
- Single axis movement by Electro Dynamic Shaker
  - Axis change by tilting test object
  - Slip table for heavier objects
  - System size is dependent on object mass and required force

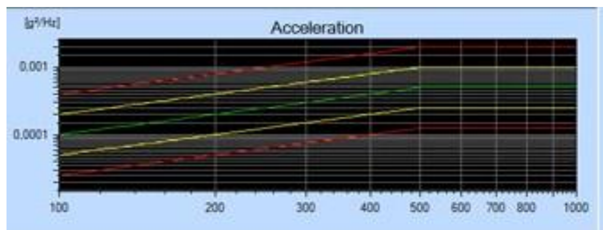




MT – Vibration exposure

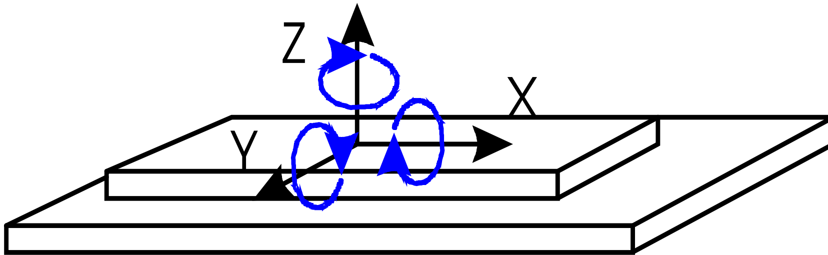
- **Example: ETS solutions M124/GT600M**
  - DC-4000Hz, max.force:1000kgf, max.acceleration:100g, max.displacement: 51mm, max.sliptable payload: 550kg
- **Exitation Controller: m+p VibPilot-4**
  - Sine & Random spectra, SoR/RoR
  - Shock Multimode: SRS analysis





MT – Vibration exposure

- **6 DOF in Omni Axial Vibration system**
  - 2Hz-10.000Hz, random vibration, max.acceleration:60grms, max.table payload: 50kg
  - 3-axis simultaneously with 4 repetitive shock hammers
  - 3-axis simultaneously rotation due to hammer mounting



MT – Shock impact

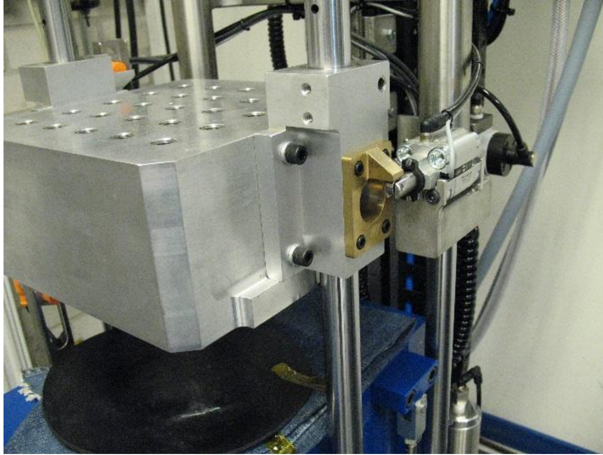
- **Shock impact**
  - Fast interconnection technology feedback
  - New test introduced for lead free SMT
  - New system with fast belt driven table
  - Signal impurity level too high → signal drift
  - Classic system too slow for 500+ drops

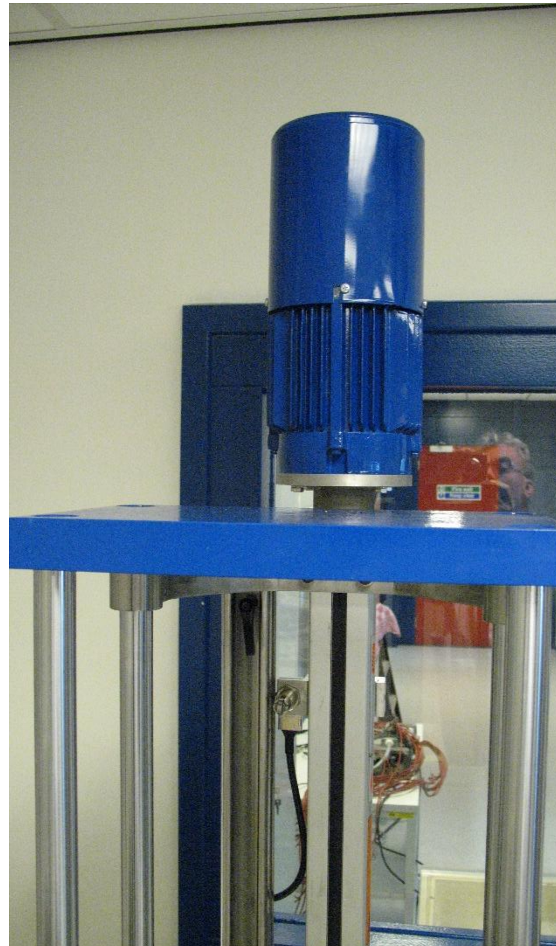
- **MASER Engineering merged them**
  - Spindle driven lift
  - Two side gripper
  - Improved shock absorber
  - Improved shock table

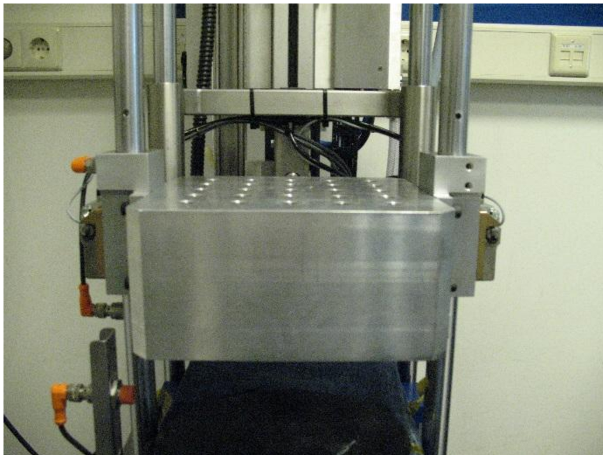
  → **Good repeatable shock signal**

  → **Wel suited for end of life test**

MT – Shock impact

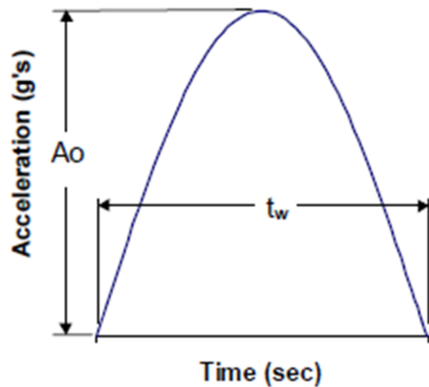


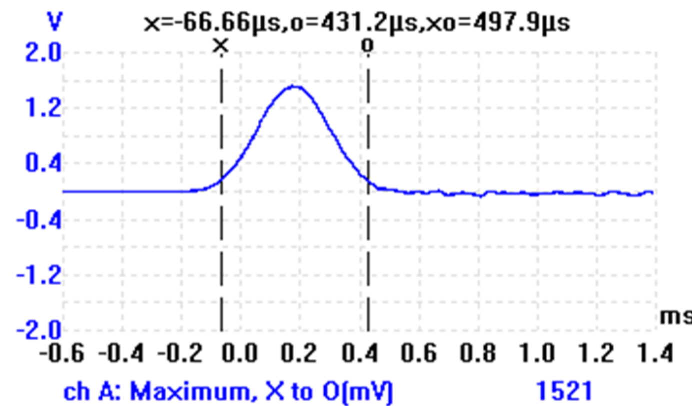




MT – Shock impact

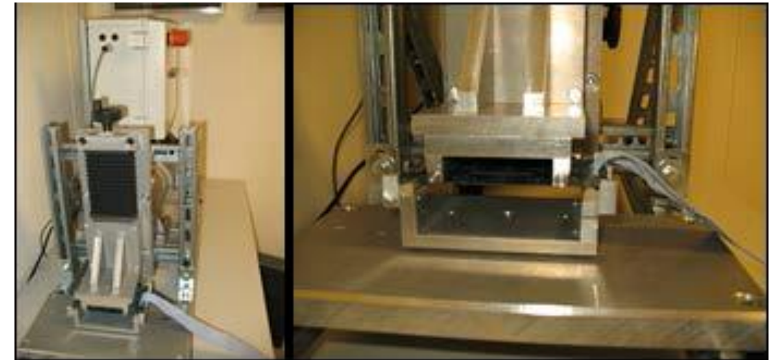
- **Two systems in action**
  - Set to same shock pulse
  - Same table mass
  - Equal signal purity
- **End of life test**
  - > 1000 drops
  - 1500g peak, 0.5ms

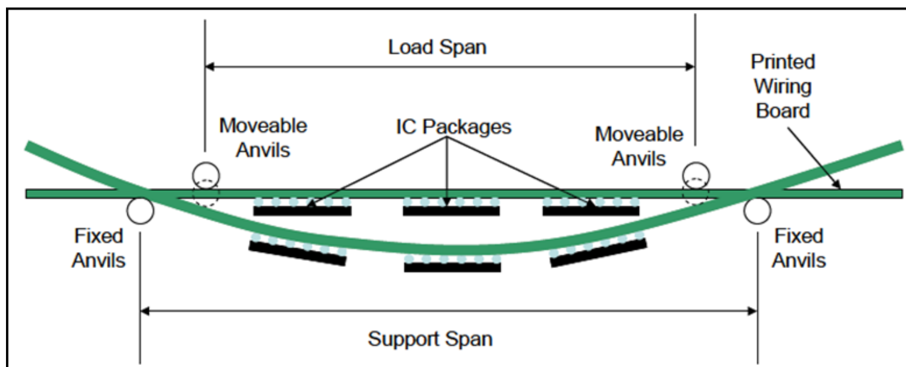




MT – Bending stress

- **Bending stress**
  - 3 or 4 point alignment
  - 2-4 mm displacement
  - 3-5 Hz bending speed
  - Free object area
  - Resistance scanner control
  - Strain gauge calibration
  - Scanner 10x bending frequency





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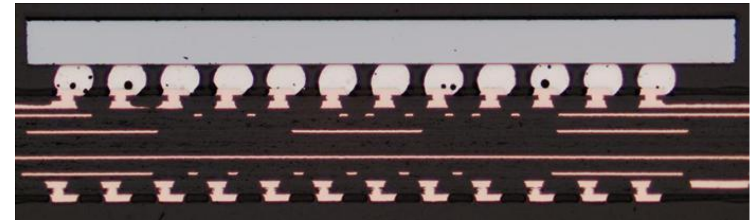
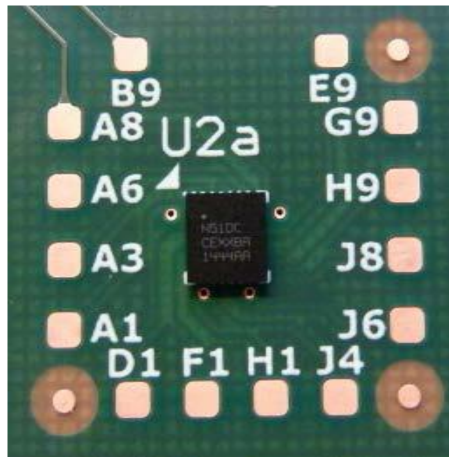
Case 1 – Component level

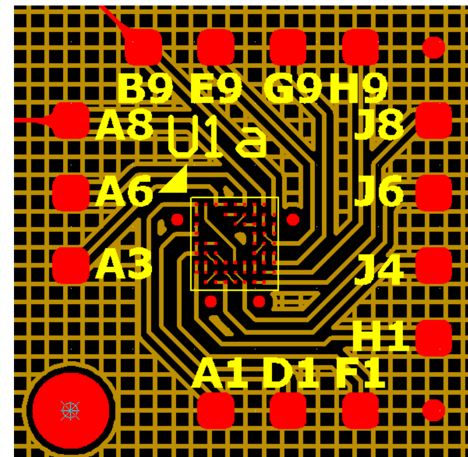
- **BLRT on chip scale package**
  - CSP with polyimide redistribution layer
  - Daisy Chain modified top metal for test purpose
  - Counter chain test board designed → Single resistor per IC
  - 12 – 15 positions per board
- **Board Level Reliability Test procedure**
  - Slow temperature cycling with resistance scanner
  - Slow 4-point bending test with resistance scanner
  - Fast drop test with glitch detection until first steady open IC

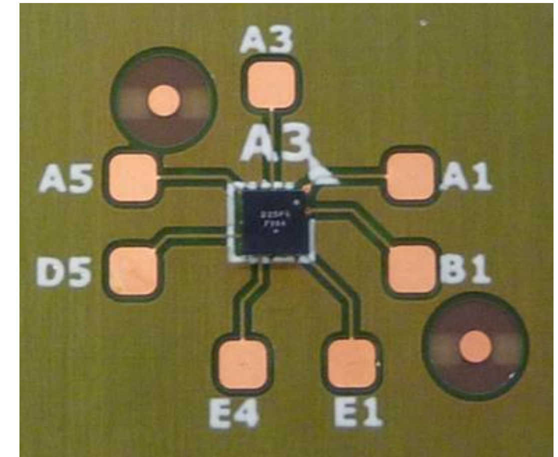
Case 1 – Component level

- **BLRT on chip scale package**
  - CSP with polyimide redistribution layer
  - Daisy Chain modified top metal for test purpose
  - Counter chain test board designed
  - 12 – 15 positions per board
  - Lead Free soldered SMT device



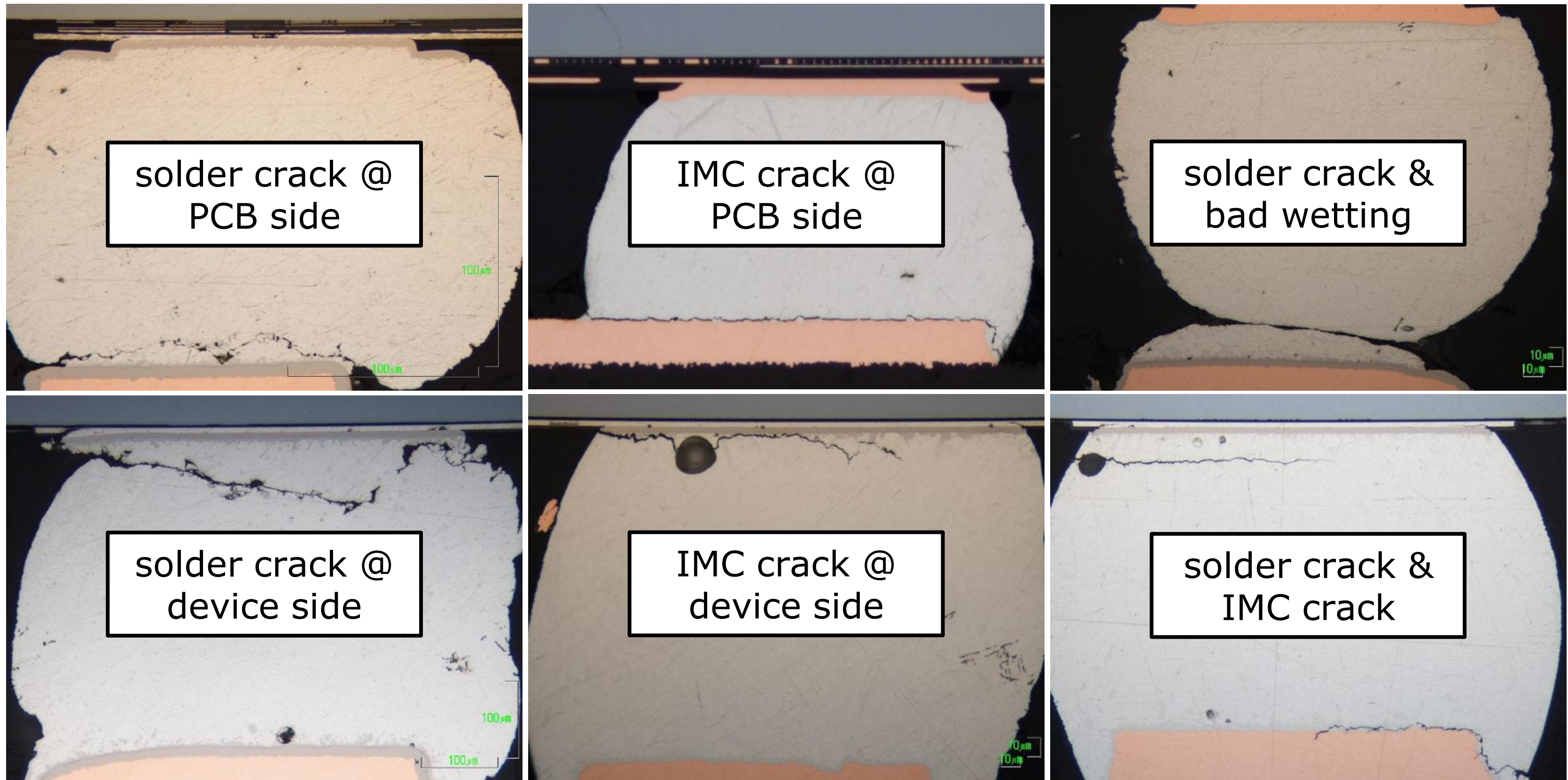






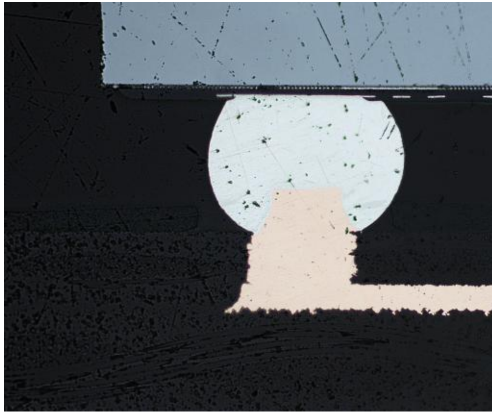
Case 1 – Component level

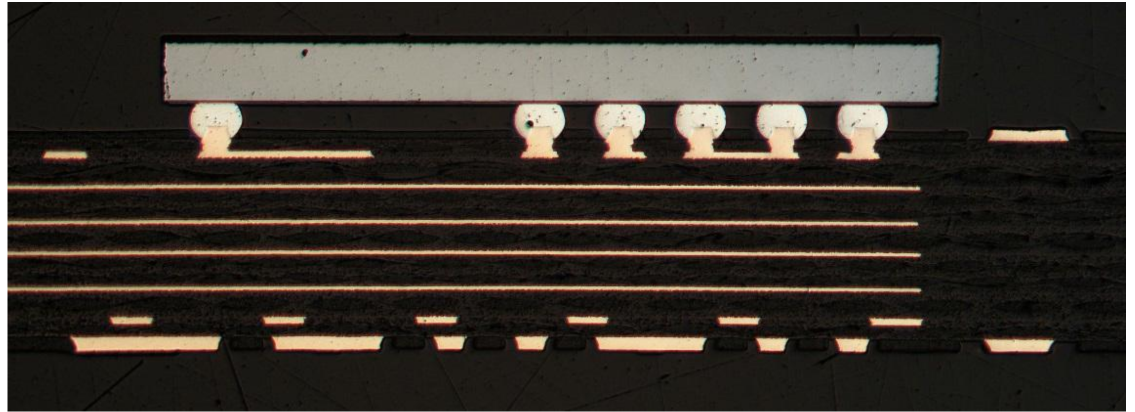
- **Row by Row cross sectioning**

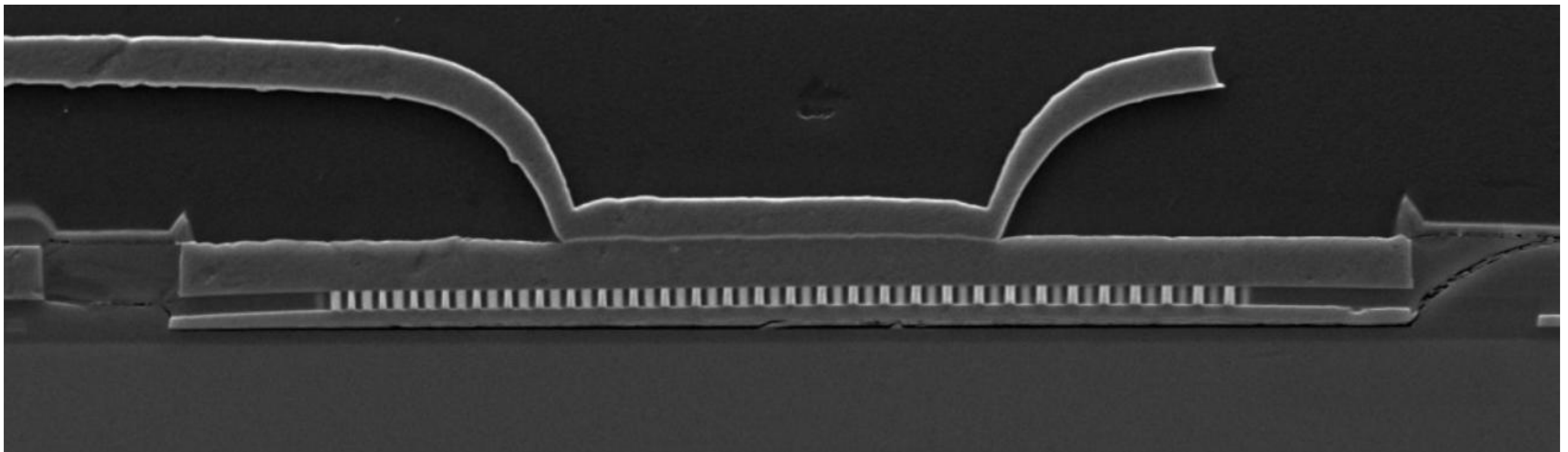


Case 1 – Component level

- **BLRT defect in the chip**



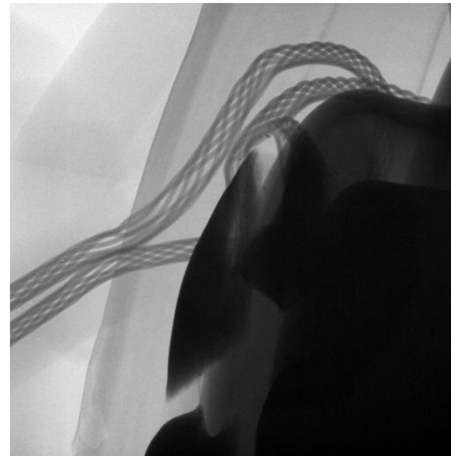
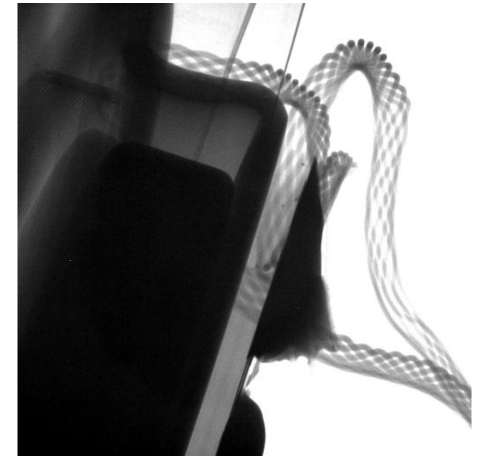
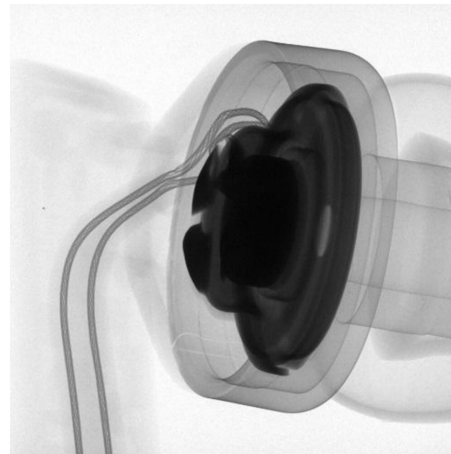
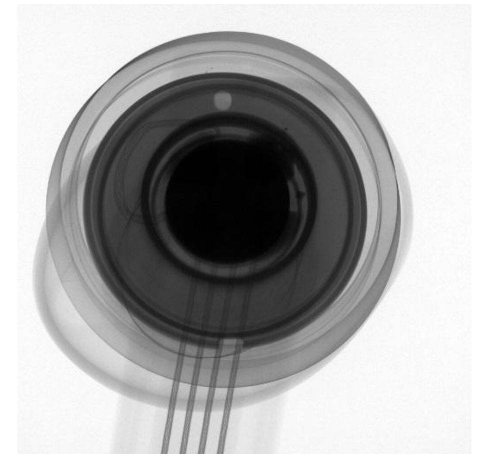




Case 2 – System level

- **Bending stress on head set wires**
  - LSP resistance drop
  - Internal movement
  - Shielding cracks
  - Poor Solder joints

- **X-ray analysis**
  - Non Destructive
  - 2D + OVHM
  - 3D CT recording
  - Address Xsie location

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- **Wearable electronics**
  - Sensitive to mechanical stress
  - Temperature based aging does contribute less
  - Exposure to both slow and fast slope endurance test
- **It is a major stressor for end of life state**
- **New and modified test tools**
  - Drop test system improvement
  - More active monitoring during shock impact
- **Physics of Failure analysis**
  - Test versions of the electronic package / housing
  - Root cause analysis
  - Stress modelling

Dank U wel voor uw aandacht!

Zijn er nog vragen?

U bent ook van harte welkom
na afloop van dit seminar op onze stand
8E062
op het PLOT paviljoen