IPC/iNEMI Reliability Summit

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Interconnect Technologies & Materials

Reliability@Sun

- High Level View
- Detail on Interconnect Reliability
- Interconnect Reliability Philosophy
- Summary
- Q & A

High Level View of Reliability@Sun

High Level View of Reliability@Sun

- System Architecture
  - RAS
    - Architect to eliminate single points of failure
    - Example #1, fans
      - Monitor torque/speed to understand when fan failure is expected
      - Design-in excess fan capacity, i.e., is 2N or N+1 required
      - Use telemetry capability to “call home” for replacement when needed
      - Hot swap replacement to eliminate system down-time
    - Example #2, use integration at the chip level & silicon scaling to reduce the number of L1, L2 & L3 interconnects
  - FIT Rates
    - Need to understand failure rates of all components & interconnects

High Level View of Reliability@Sun

- System Design
  - > Simulation
  - > Test Vehicles
  - > Verification of simulation models
  - > Layout design rules
    - – Interactive design rule enforcement
  - > Multiple levels of design reviews
    - – Product engineering, OPS engineering, Suppliers...
  - > On-site DFM & DFA review by suppliers
  - > Post-check prior to fab sign-off & release to fab

High Level View of Reliability@Sun

- Component level qualification
  - > Pre-qualification of laminate materials
  - > L1 & L2 interconnect qualification
- PCB Fabrication
  - > On board or on panel process monitors
    - – Impedance, DC resistance, CAF, IST
  - > First article report with Cpk data
    - – Requires action plan if inadequate Cpk
- Assembly
  - > L2 & L3 interconnect qualification
  - > Use strain gages to monitor PWB strain during board assembly, test & shipment & to optimize process

High Level View of Reliability@Sun

- System Bring-up
  - > DVT (Design Verification Test)
    - – Signal integrity DVT
    - – Functional DVT
    - – Configuration DVT
  - > RQT (Reliability Qualification Test)
    - – Run sufficient number of system hours to validate MTBF
      - – Quantity of systems & time...
  - > ORT (Ongoing Reliability Test)
    - – Sample plan selected to detect a change in reliability baseline

High Level View of Reliability@Sun

- Field Operation
  - > Continuous System Telemetry - System variables continuously sampled & recorded, i.e., "Black Box"
  - > Data analyzed remotely using advanced statistical pattern recognition software (MSET – Multivariate State Estimation Technique)
  - > MSET software can identify onset of potential failures & allow for proactive correction
  - > Telemetry harness captures actual field use conditions, aiding correlation between accelerated stress testing & end-use lifetime

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Detail on Interconnect Reliability

- Solder Joint Reliability
- CAF Testing
- Via reliability testing
- Hi-Pot testing

Solder Joint Reliability

- Solder joint integrity test assessment methods
  > Component-level
    – Solder ball attached to component
  > Board-level
    – Component attached to PWB

Component & assembly suppliers need to look at both sides of this issue, not just one side...

- Solder joint stress conditions
  > Thermal
    – Power cycling (main & mini) in actual use
    – Ambient operating temp (cyclic & high temp)
  > Mechanical
    – Component handling, test & shipment
    – Board assembly, handling test & shipment

Solder Joint Reliability, cont'

- Solder joint stress conditions, cont'
  - Mechanical
    - Component handling, test & shipment
    - Board assembly, handling test & shipment
  - End use
    - Drop/impact (test simulates 6 foot fall off a lift-gate truck)
    - Keypad
- Standardized test methods
  - Component-level
    - Solder ball shear (JESD22-B117A)
      - Low-speed (0.1 - 0.8 mm/s)
      - High-speed (100 - 4000 mm/s)

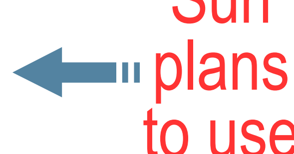
Solder Joint Reliability, cont'

- Standardized test methods, cont'
  - Solder ball pull (release 6/2007)
    - Low-speed (0.1 - 15 mm/s)
    - High-speed (15 - 1000 mm/s)

NEW!

- Board-level
  - Temperature Cycle (IPC-9701A)
  - Monotonic Bend (IPC/JEDEC-9702)
  - Cyclic Bend (JESD22-B113)
  - Mechanical Shock
    - Handheld devices (JESD22-B111)
    - Large devices & sub-assemblies (IPC-9703 draft)

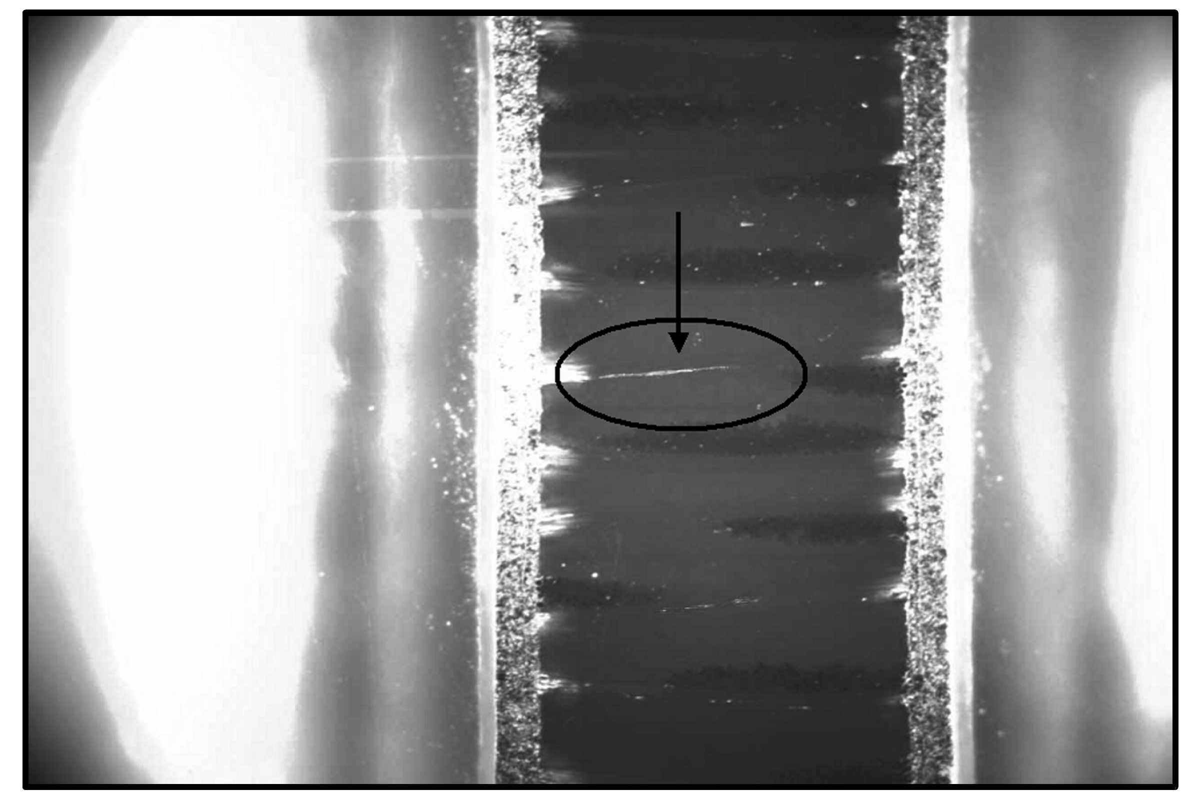
Applicable to handheld devices



Sun plans to use

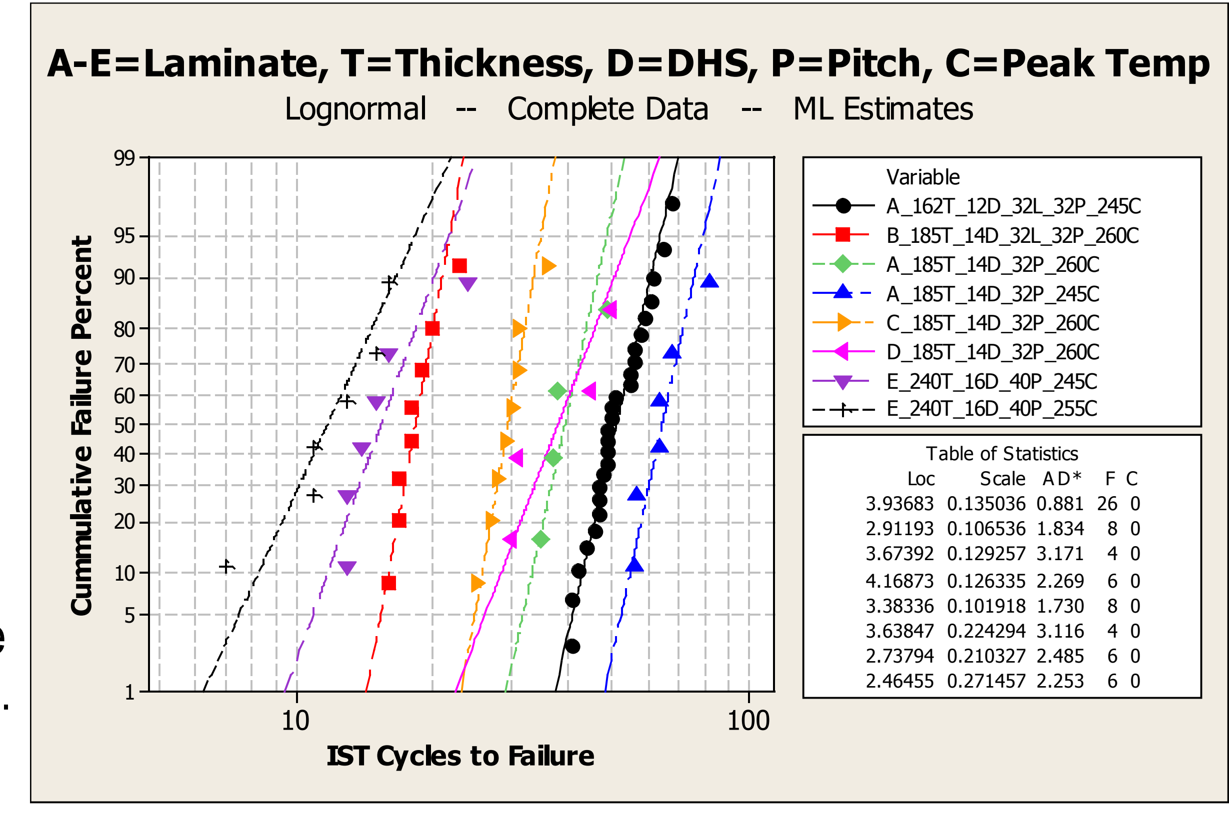
CAF Testing (IPC-TM-650 2.6.25)

- Necessary requirement as pitch & drill edge-to-edge pitch decreases
- Long term reliability issue driven by
  - Temperature
  - Humidity
  - Bias voltage
- Key factors are:
  - Laminate material
  - Layer ionic cleanliness
  - Amount of drill fracture
- Moving from qualification to baseline with on-board coupons



Via Reliability Testing

- Qualification
  - > 3x & 6x thermal stress
    - (IPC-TM-650 2.6.8)
  - > APD-Oil-T-Shock
    - (IPC-TR-579)
  - > Interconnect Stress Test
    - (IPC-TM-650 2.6.26)
  - > Highly Accel Thermal Stress
    - (MIL-STD-202 Method 107)
  - > Kelvin 4-probe of via resistance
    - Measure, 6x reflow, measure...



- Process control
  - > Thermal stress used for routine lot acceptance
  - > IST used for product development & quarterly process baseline
  - > Sun requires cycling to failure & allows testing at reflow peak
- Able to predict field life from thermal testing at multiple temperatures

Hi-Pot Testing

- Required for UL compliance, test is...
  - 500 VDC minimum, 50 MΩ minimum
  - 50 volt/sec ramp to 500VDC then 5 second hold
- Issues
  - Boards used to have GND & one or two voltages
    - Three combinations to test or 45 seconds to test per board
    - Easy for fabricator to find plane combinations to test
  - Today boards have very complex power domains
    - Have one part number with 14 voltage potentials on 42 nets
    - Total combinations are [n*(n-1)]/2=91 or 22.75 minutes/board
    - Testing needs to be well documented by Sun
    - Eliminate combinations where there is no adjacency (91 ▶ 15 or 3.75 min)
    - Fabricators need to use a bed of nails for Hi-Pot testing

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Interconnect Reliability Philosophy

- Use industry standards whenever possible
  - If standard does not exist, work with industry to develop
    - IPC/JEDEC-9704 Strain Gage, IPC/JEDEC-9702 Monotonic Bend, IPC-TM-650 2.6.25 Conductive Anodic Filament (CAF) Resistance Test, IPC-9701 Solder Joint Reliability, IPC-4101B Base Material...
  - Collaboration & partnership is a part of Sun's DNA
    - Active in IPC, iNEMI, HDPUG, JEDEC, University partners...
- Collect data to make decisions
  - Use industry standard test methods to collect data
  - Use Sun specific requirements for the pass/fail criteria
  - Baseline supplier processes with meaningful data & work on continuous improvement

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SUMMARY - Reliability@Sun

- System reliability is a complex task
  - 1st need to minimize un-reliability in the system architecture
  - then need to aggressively work on the remaining largest contributors
- You must understand the reliability of all components & of all interconnects
  - Data, data, data...
- The best & most sensible practice is to collaborate with the industry on standards because...
- Sun is not big enough to do it alone

Thank You
Any Questions?

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