



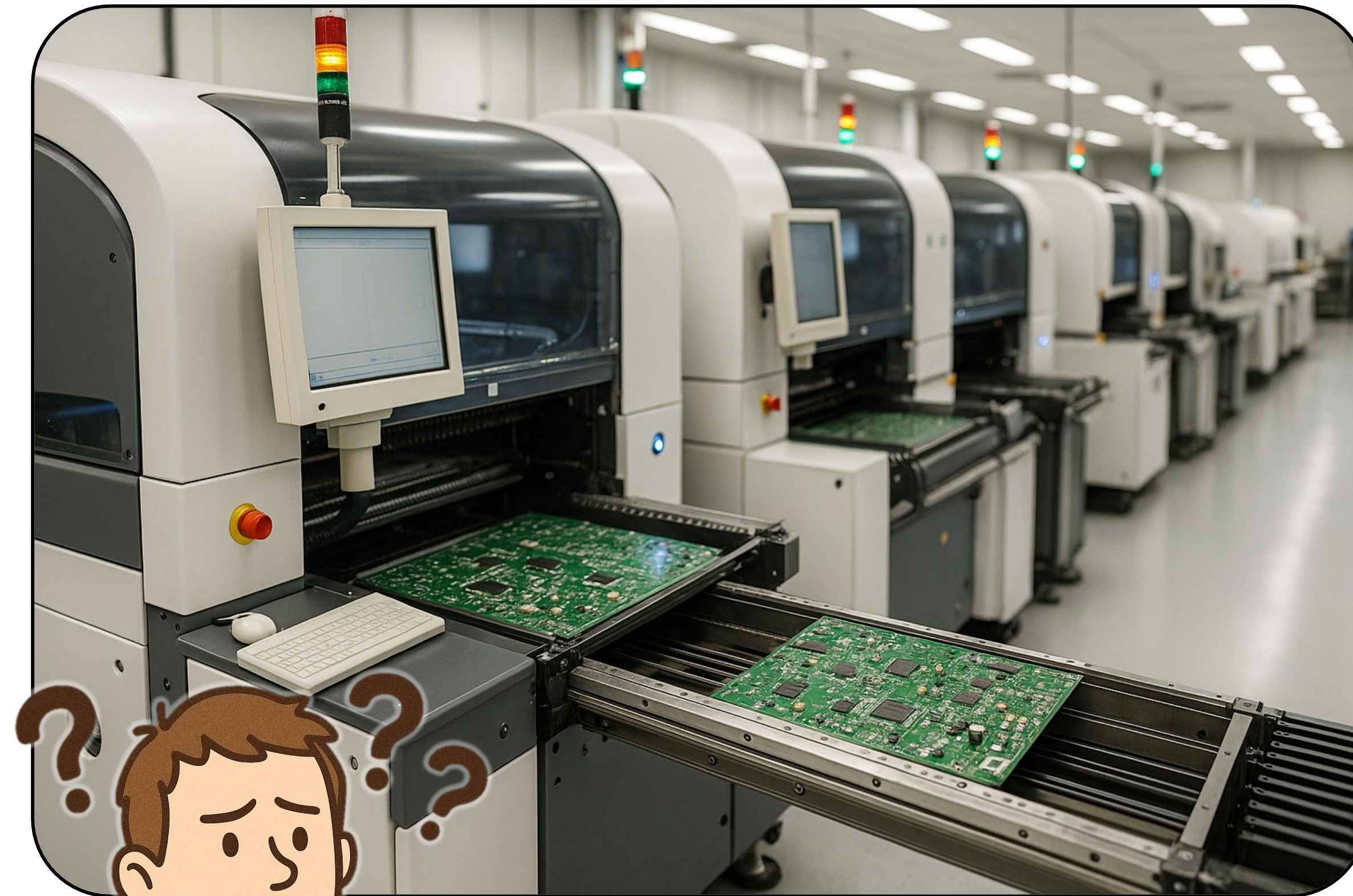
Next-Generation Techniques in Electronic Failure Analysis

Non-Destructive Forensics for Early Issue Identification

Steven Crane, PhD, PE, CFEI

Nov 12, 2025

Introduction



- Early-career Engineer
- Easy Line Bring-up
- First Ramp Units Failing
- Exec Team Needs Answers



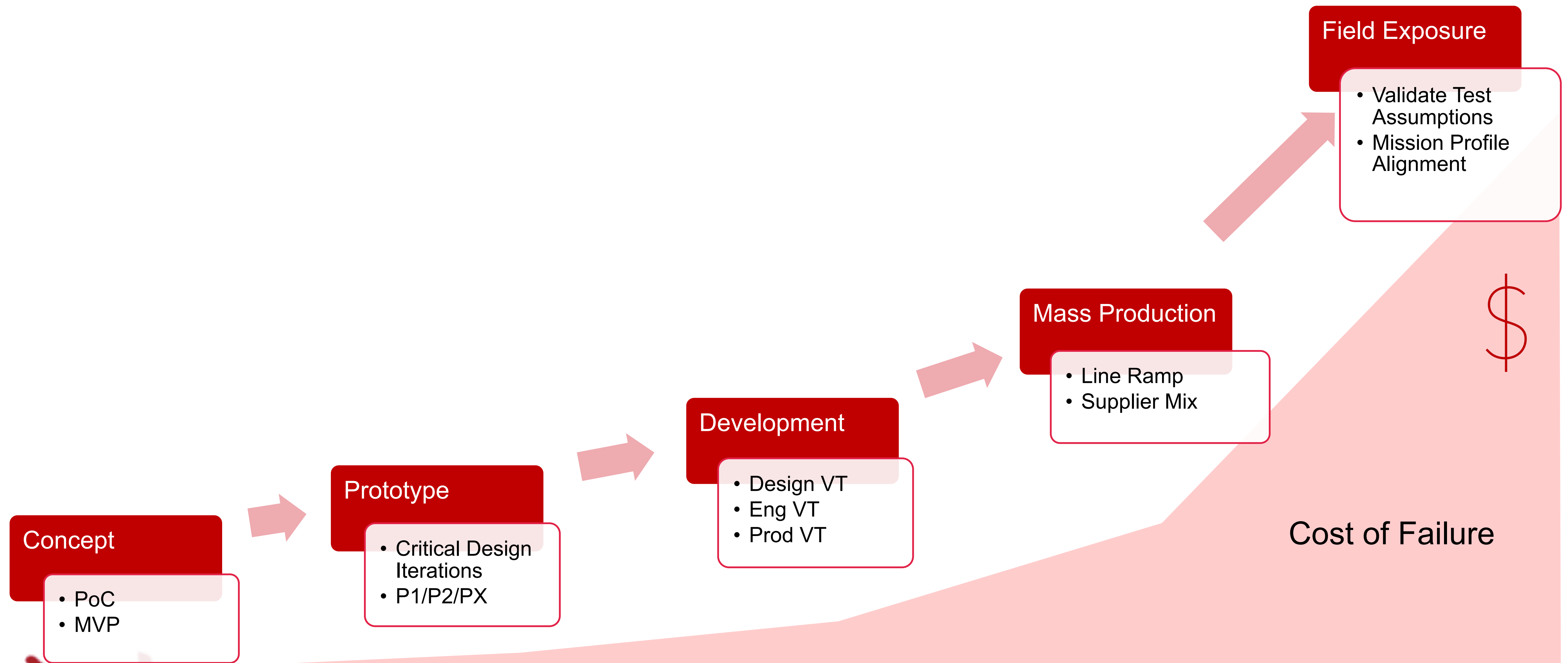
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Forensics in the Mass Production Workflow





Burying the Lede

Case Background

- Mobile devices malfunctioning out of the box or soon after
- ~2000 defective parts per million (dppm)
- Prelim triage show variety of symptoms, not always present at pack-out
- Via open risk across board
- Most pervasive fault is memory communication error
- NAND vendor shows no spike in issues

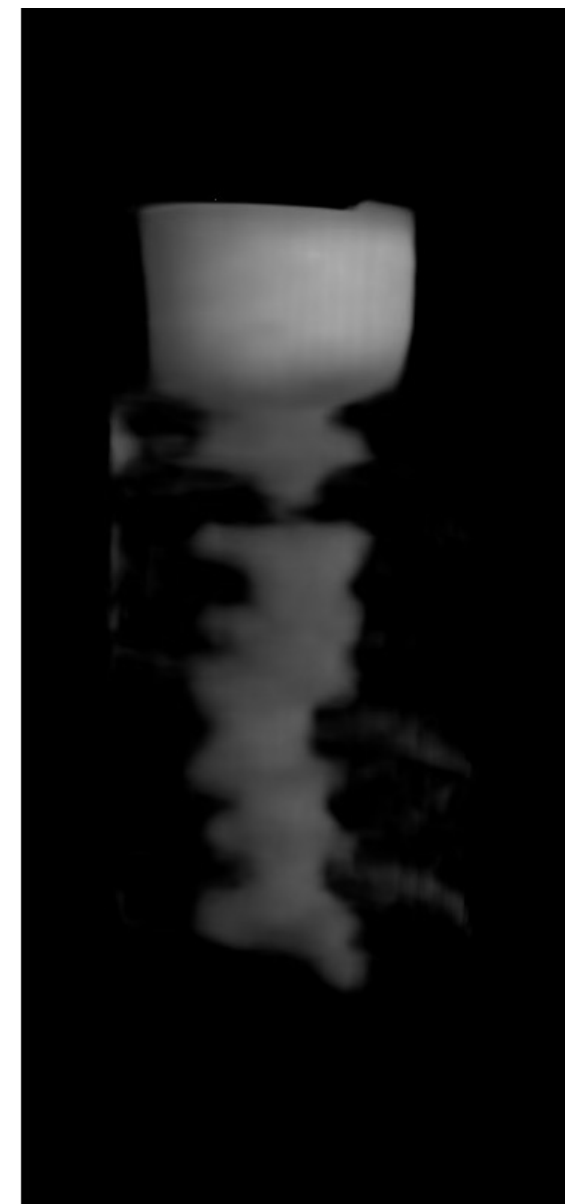
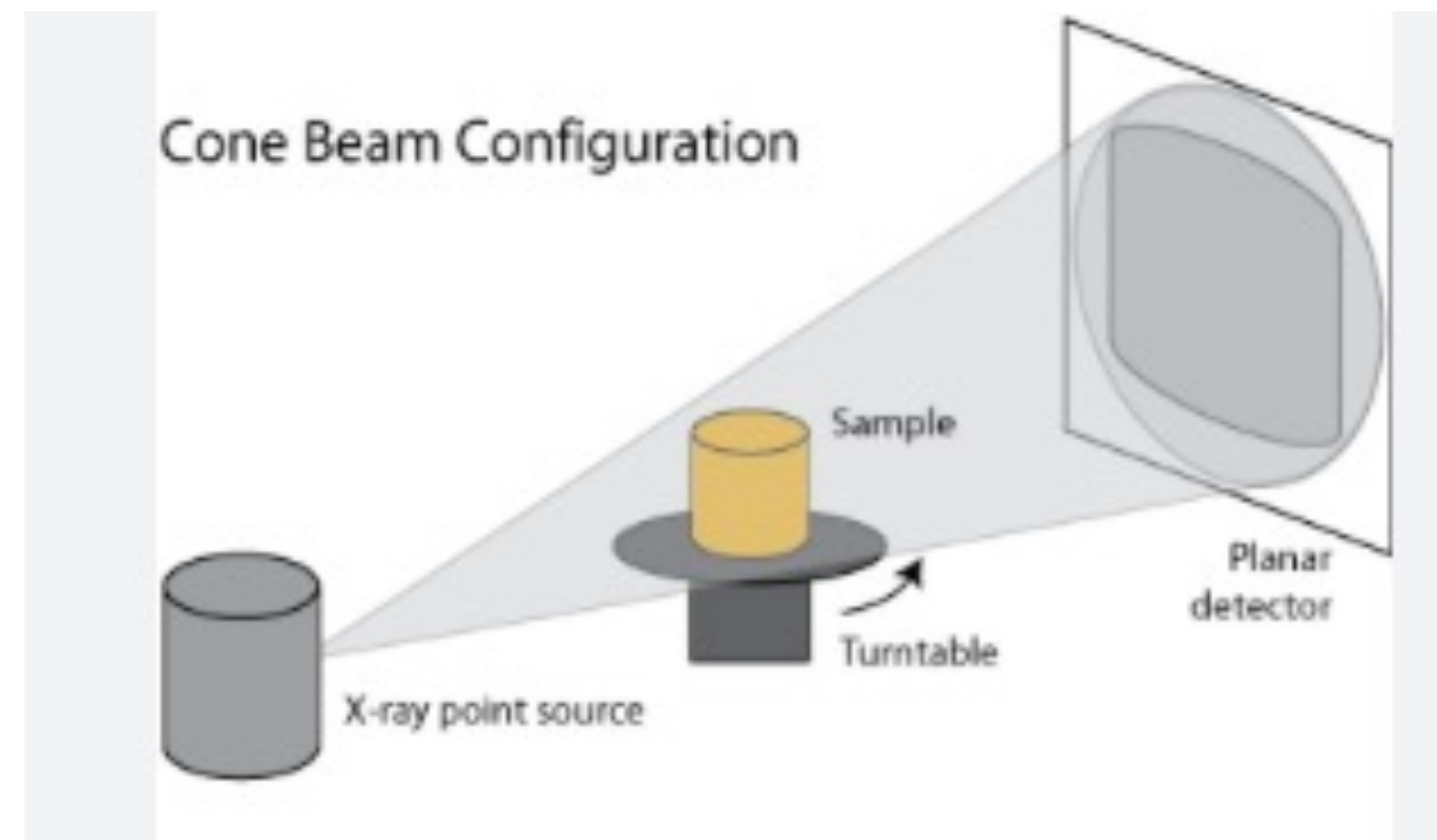


X-Ray Computed Tomography Valuable First Step

- Voltage Range: 10 kV – 225 kV
- Minimum Focal Spot Size: ~900 nm
- Pixel Pitch: 100 - 200 μm
- Detector Size: 8 x 10 in [20.3 x 25.4 cm]
- Nominal Part Envelope: 19.5 x 24 in [50 x 61 cm]
- Maximum Focal Distance: 53 in [134.6 cm]
- Part Travel:
 - Horizontal: 13.8 in [35.1 cm]
 - Vertical: 24 in [60.96 cm]
 - Source to Detector: 32 in [86 cm]
 - Rotation: 360° Continuous

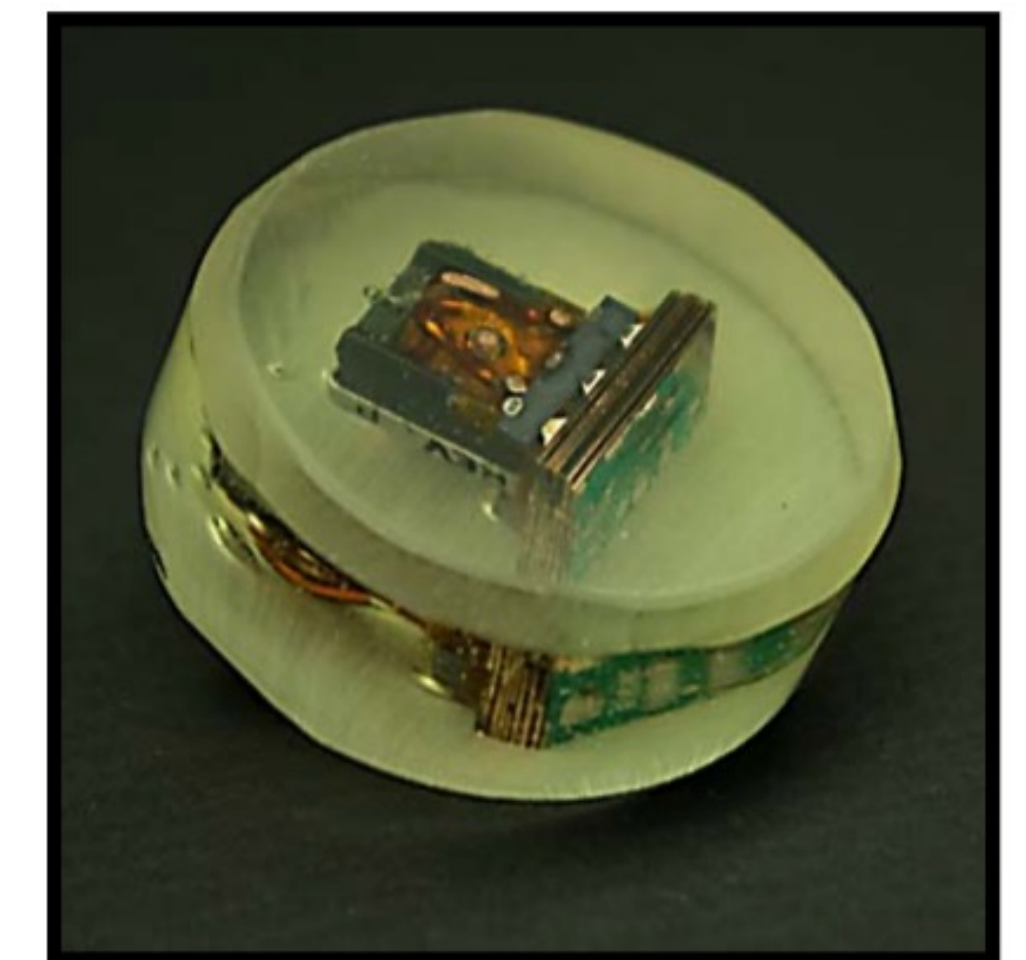
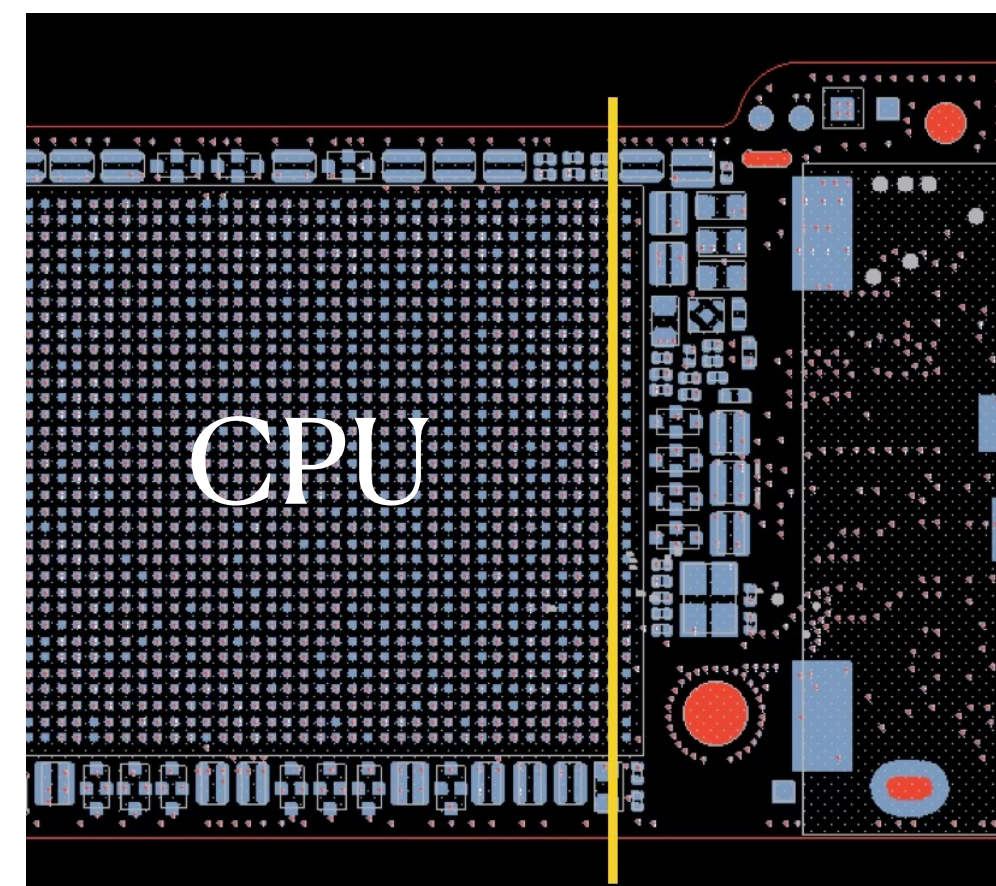
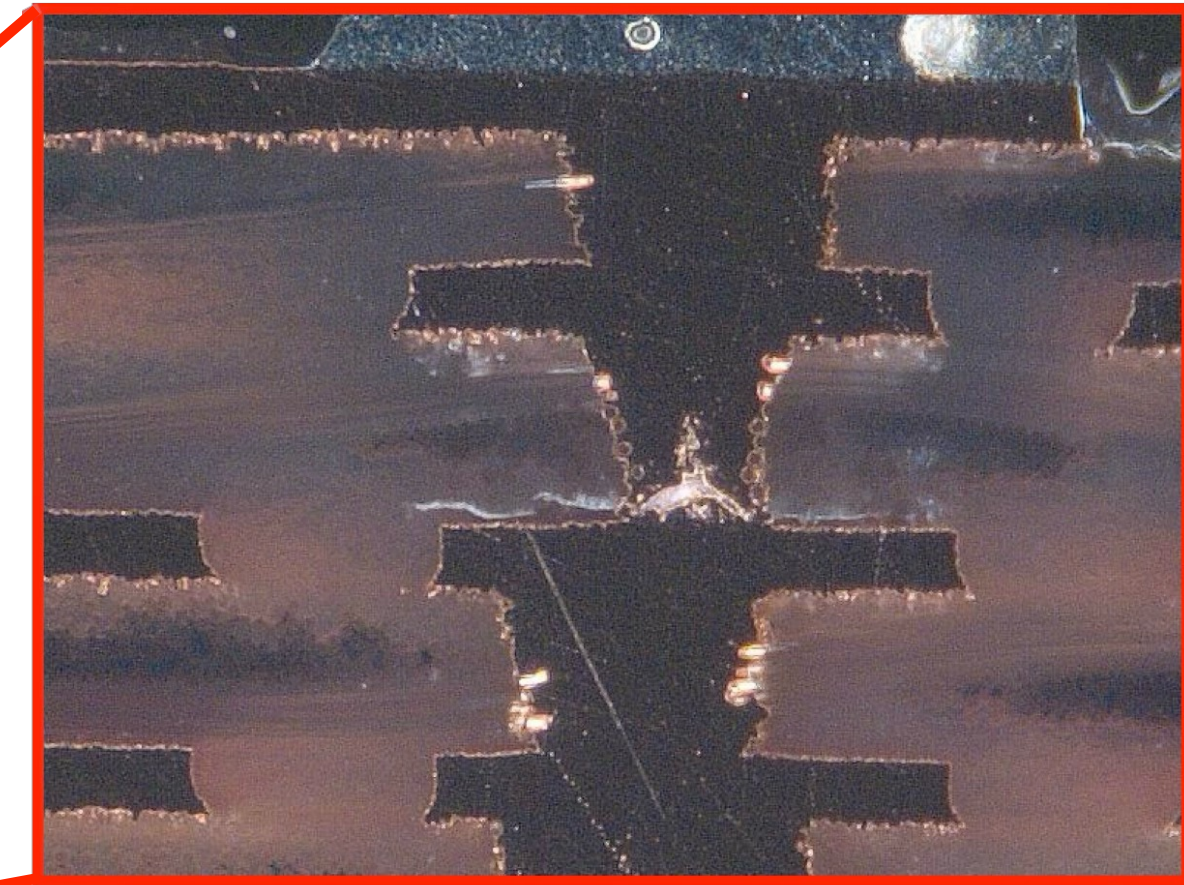
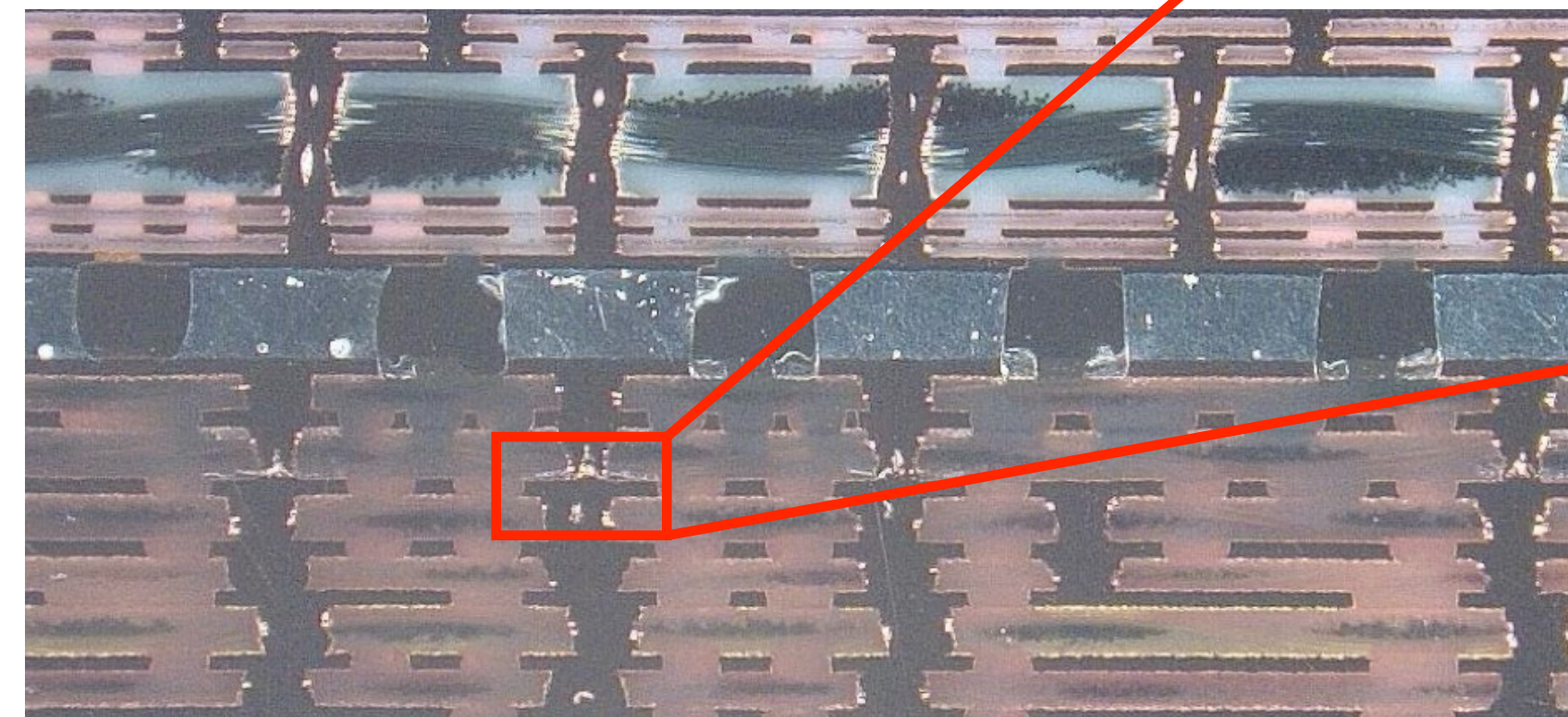


Confirming the Cause



Suspect Via CT

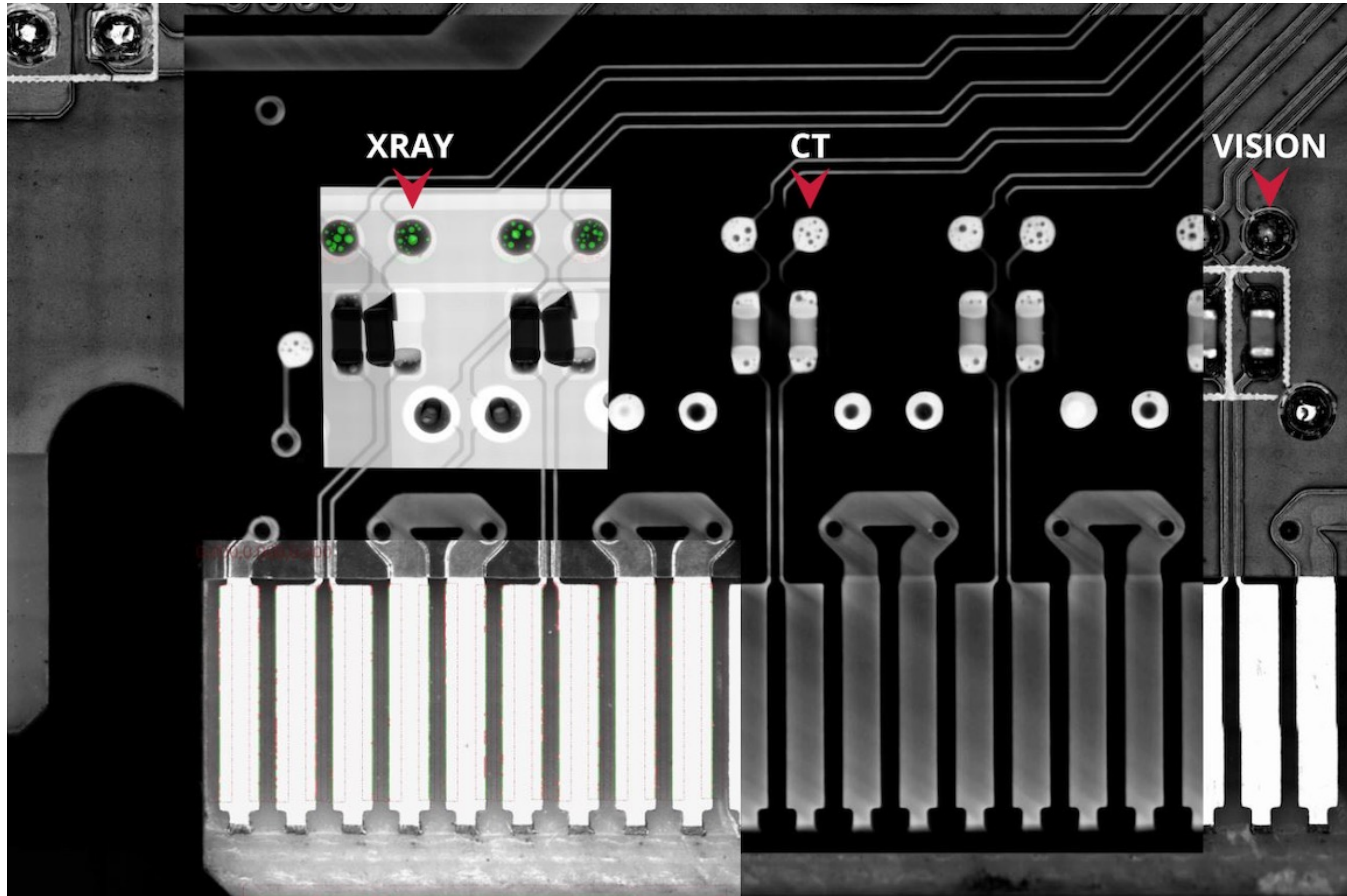
Ref: carleton.edu



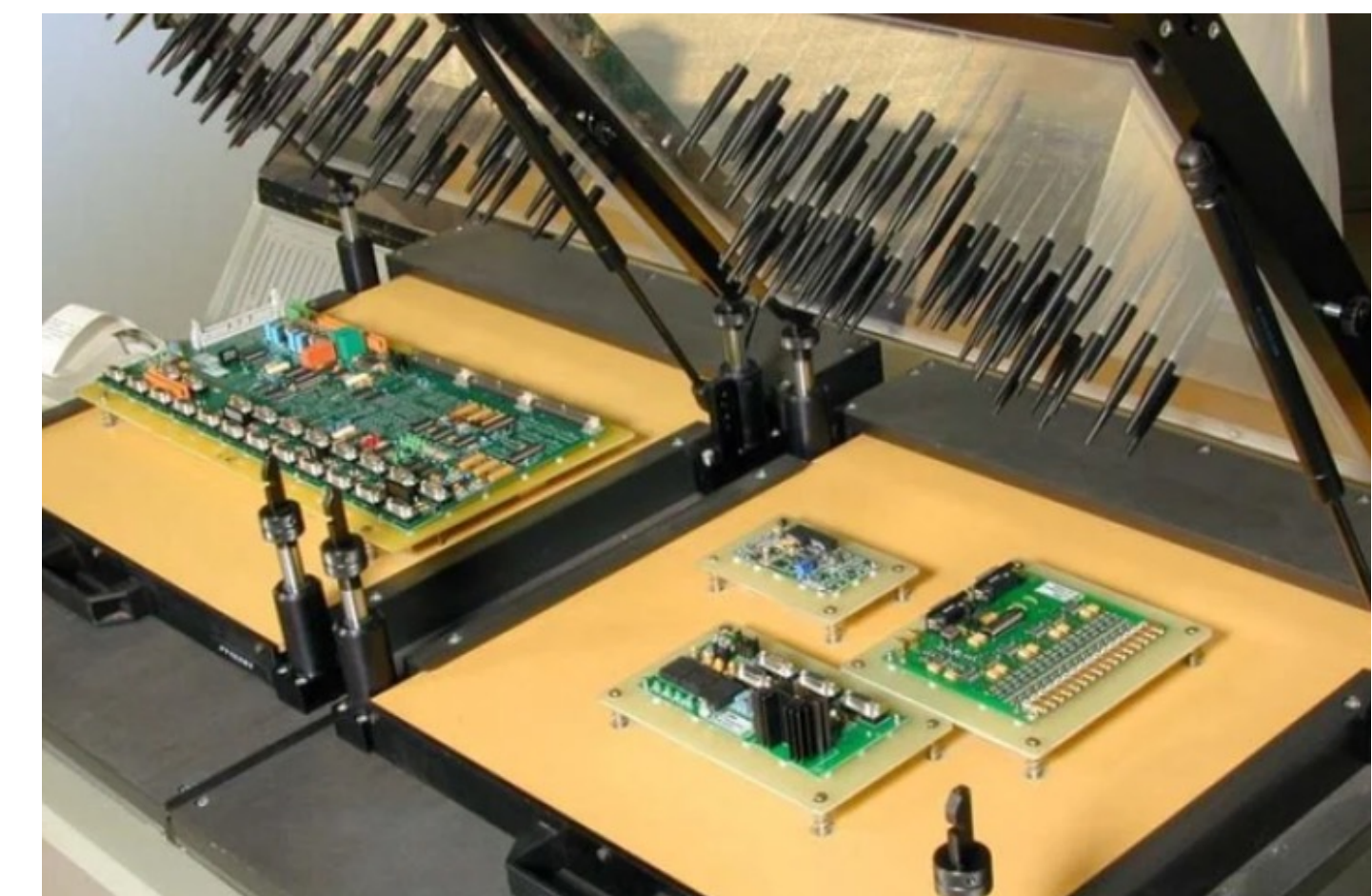
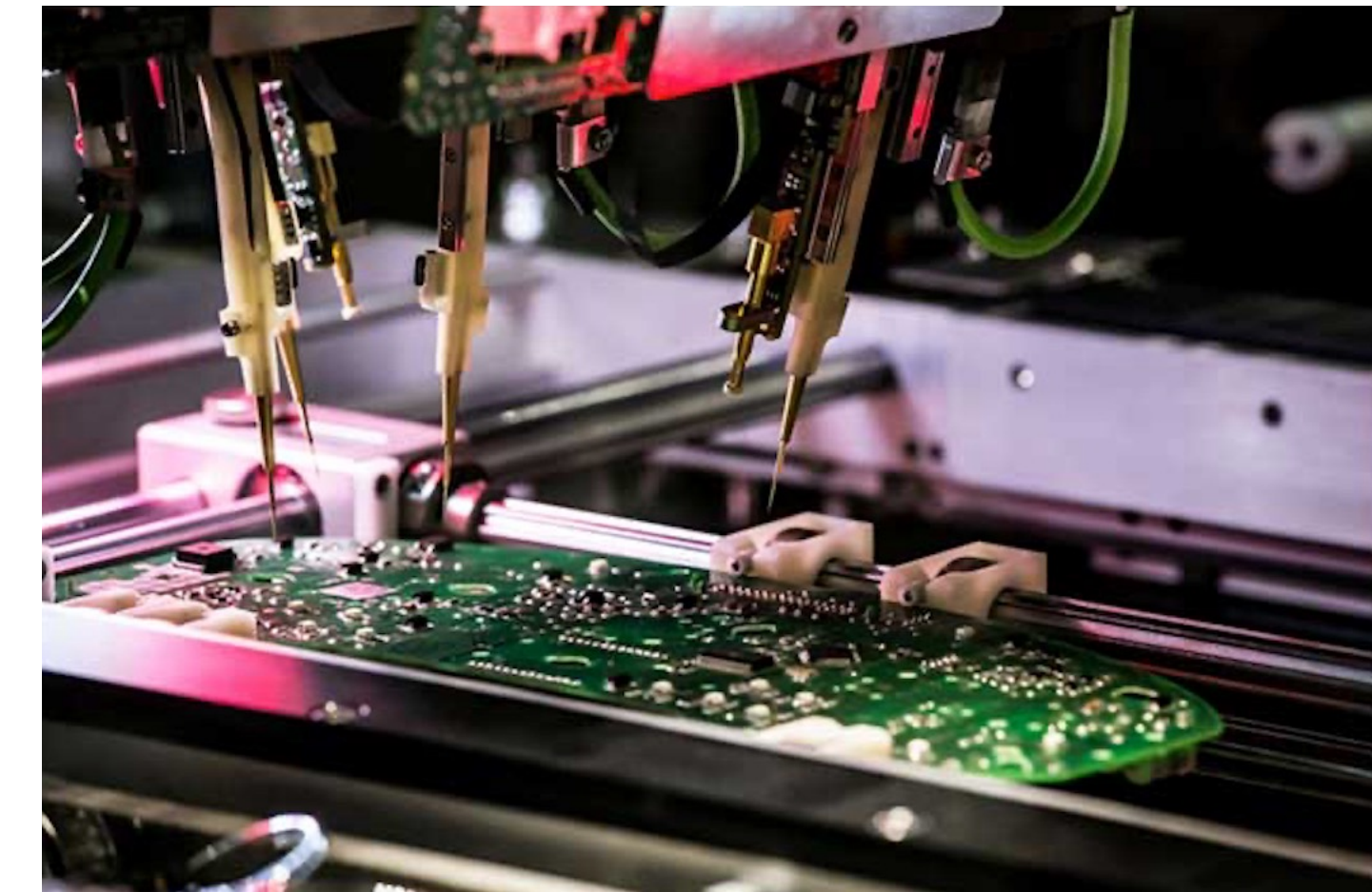
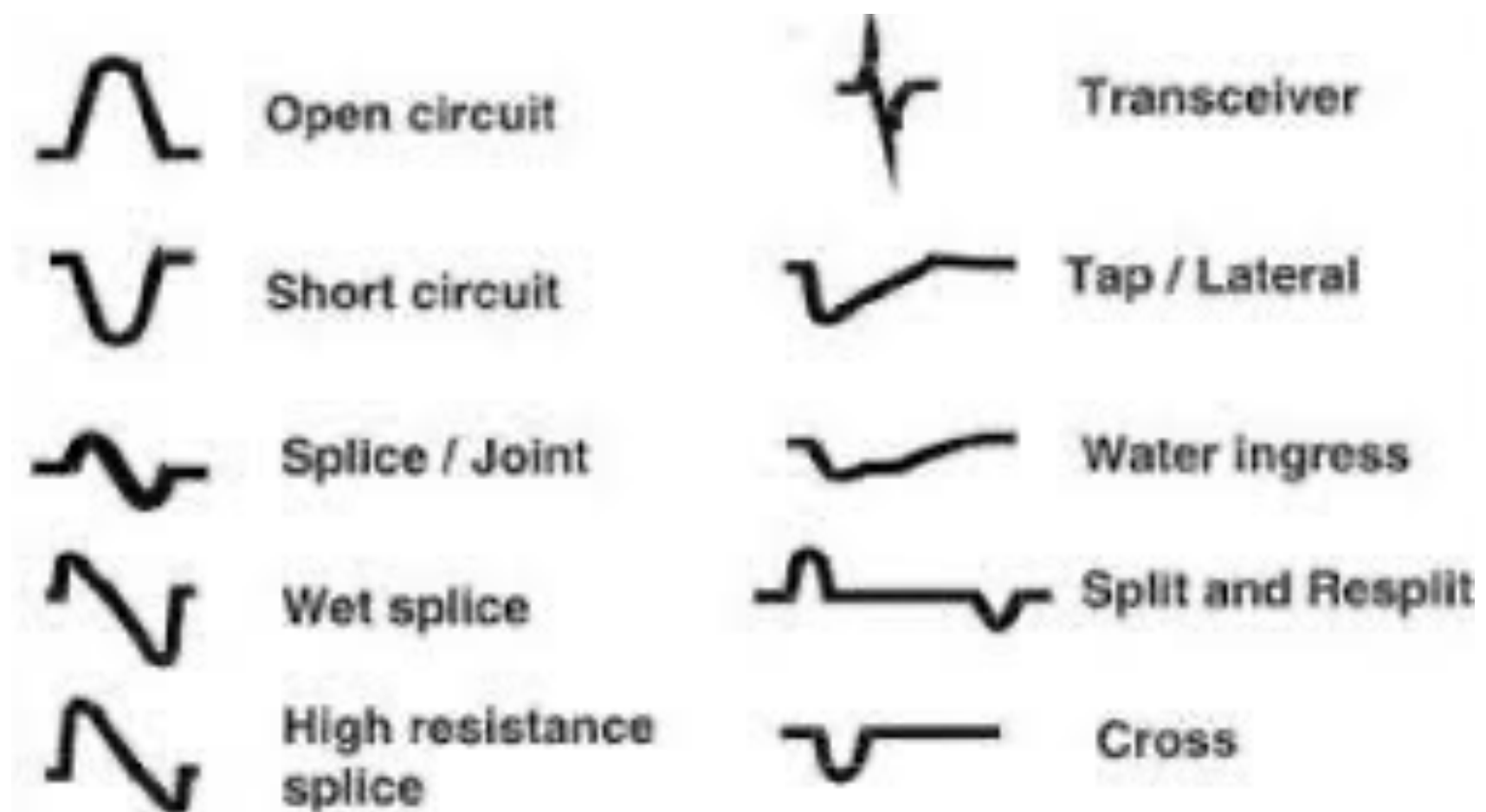
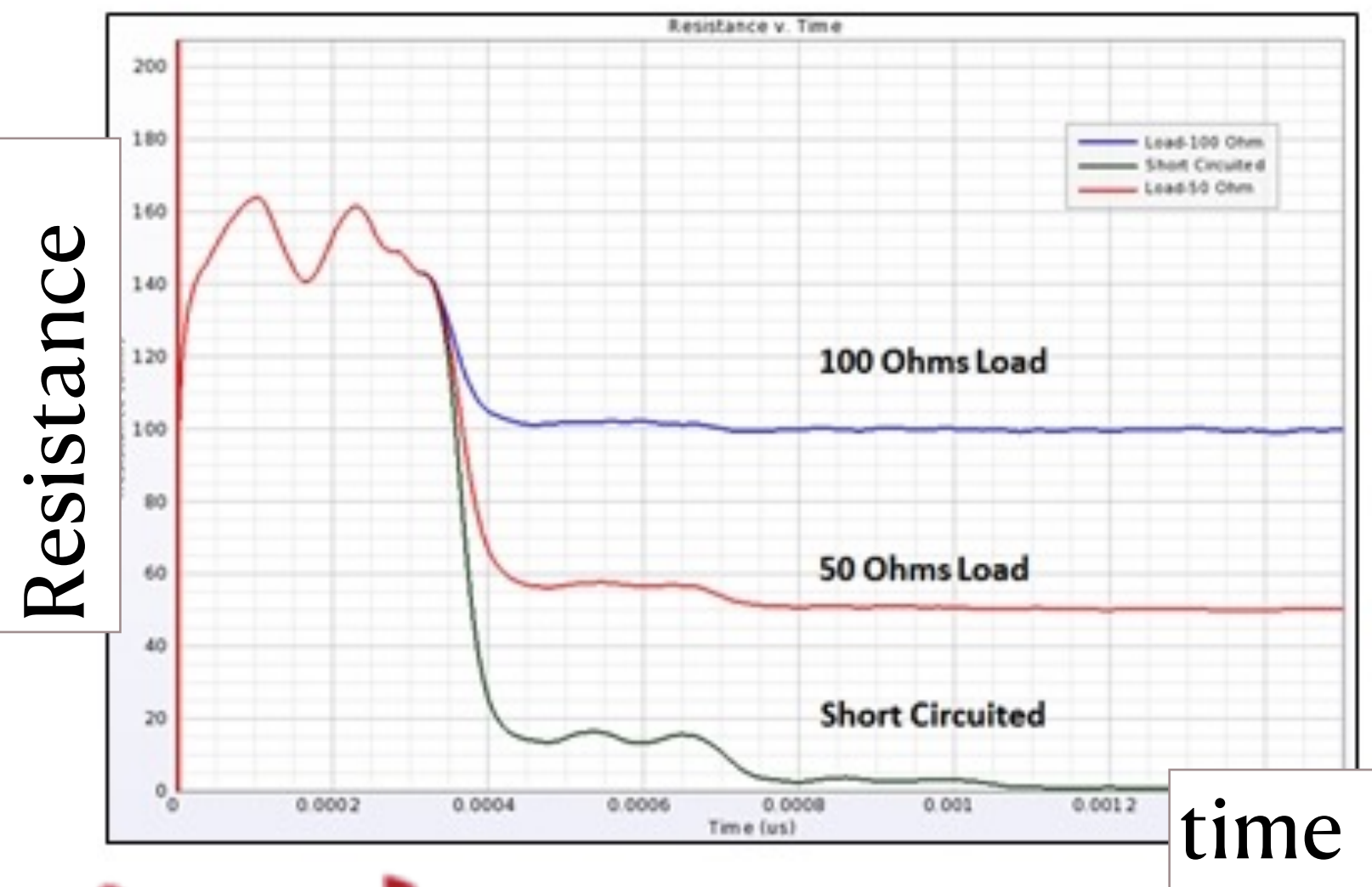
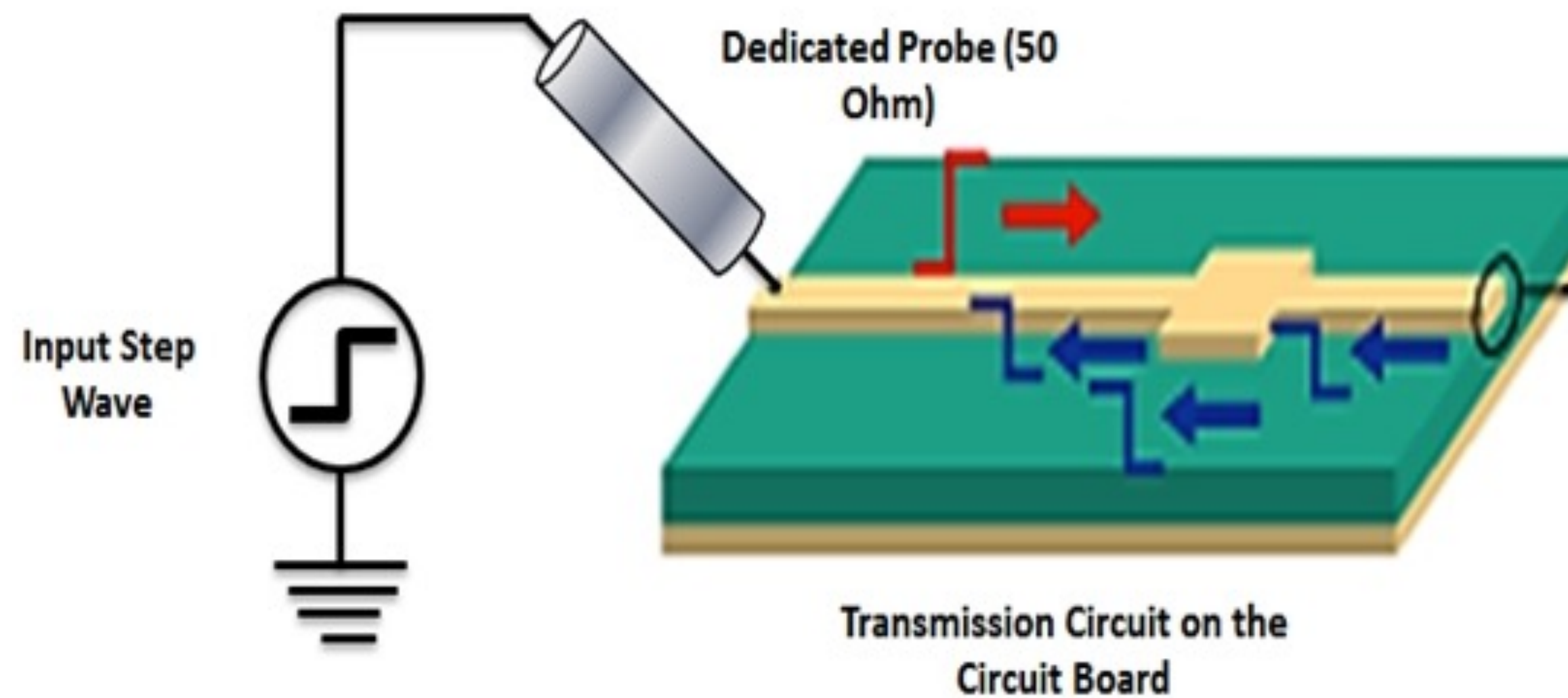
Traditional sectioning techniques very time-intensive
→ Non-destructive first!

Ref: circuitinsight.com

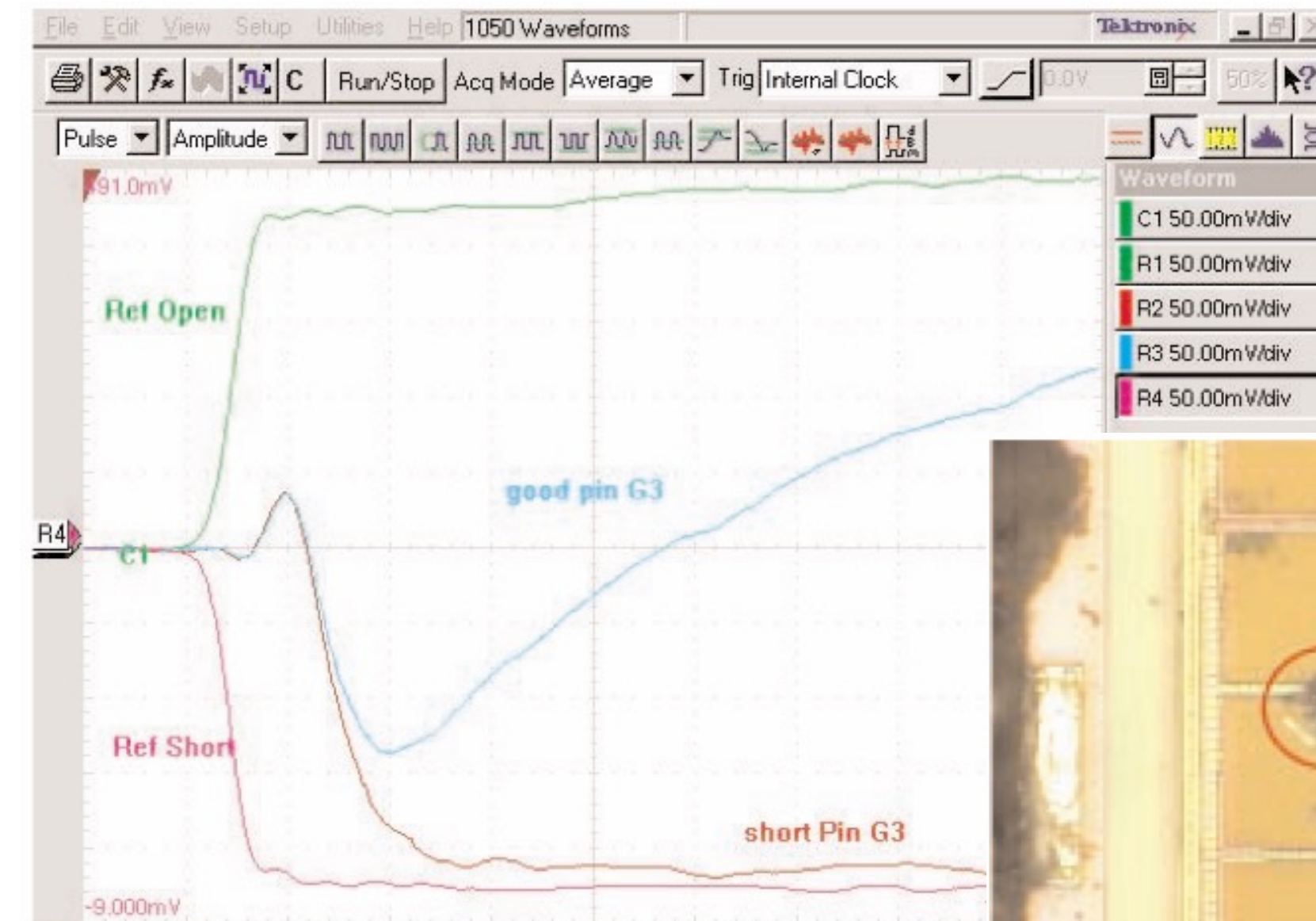
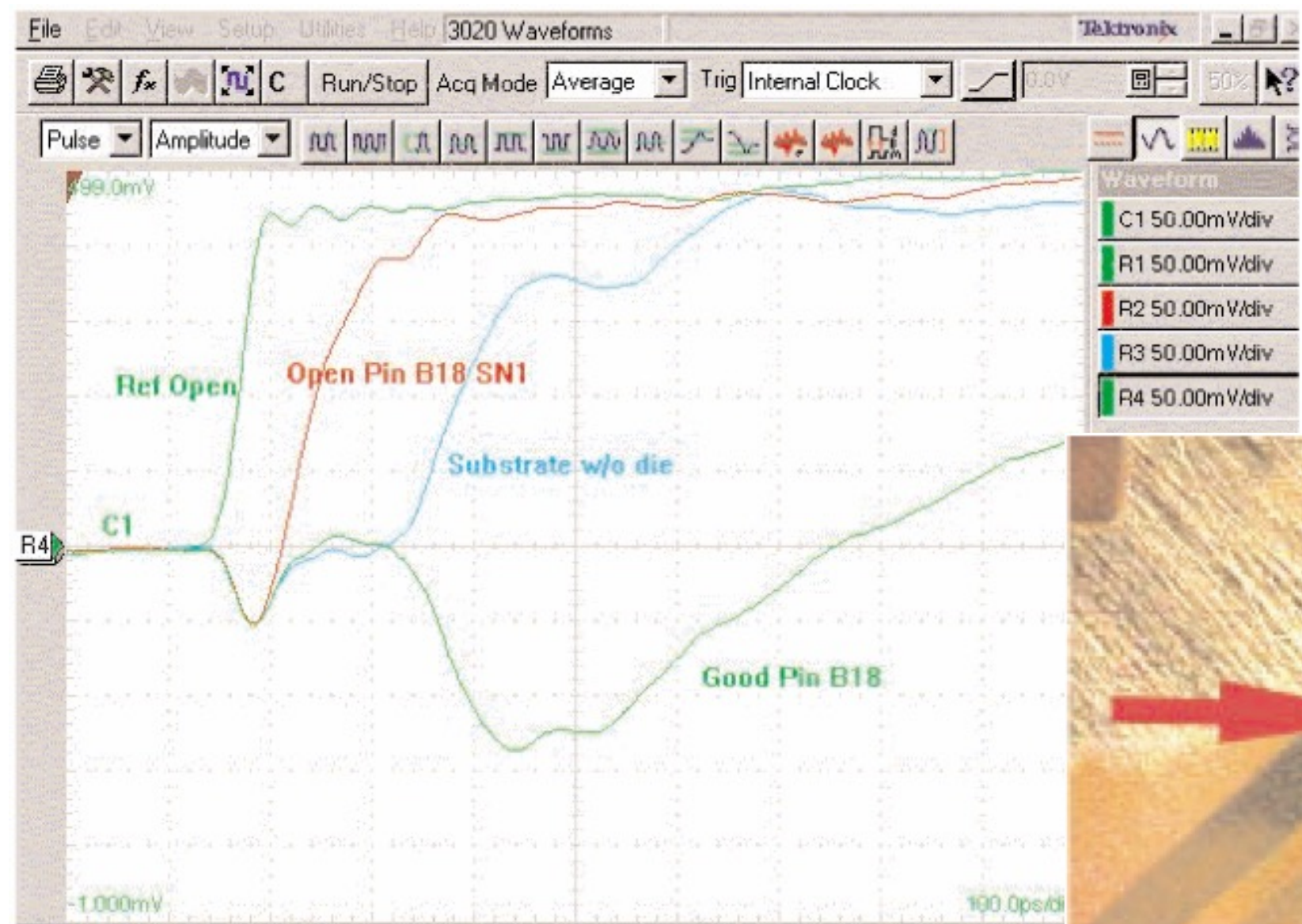
Non-Destructive Evaluation Benchmarking



Time Domain Reflectometry – Catch Issues Online



Time Domain Reflectometry – Catch Issues Online

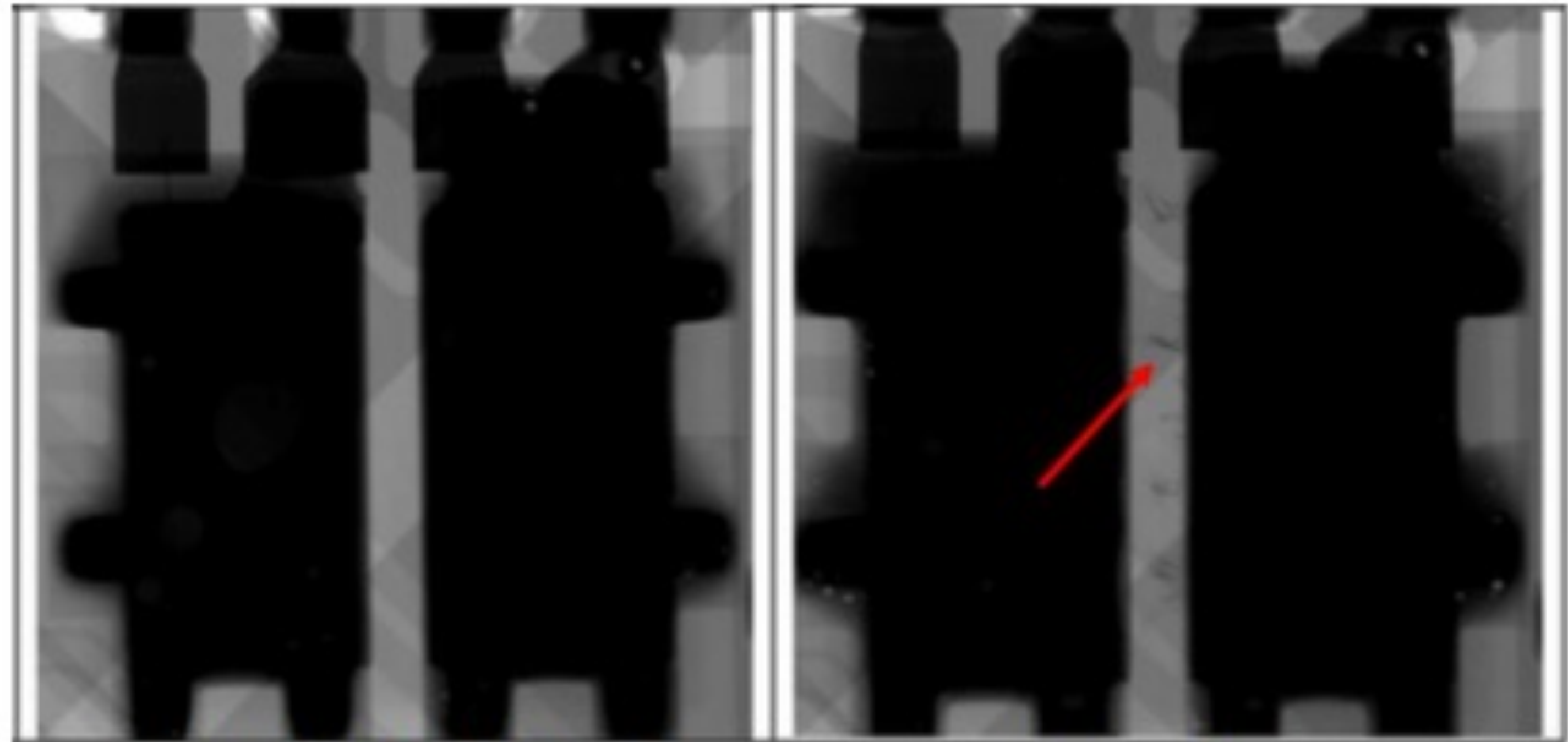




Forensics in Flux

Case Background

- High-Temp/High-Humidity Testing Failures (4F/6T)
- X-ray verifies possible shorting under BGA IC
- What do we do?



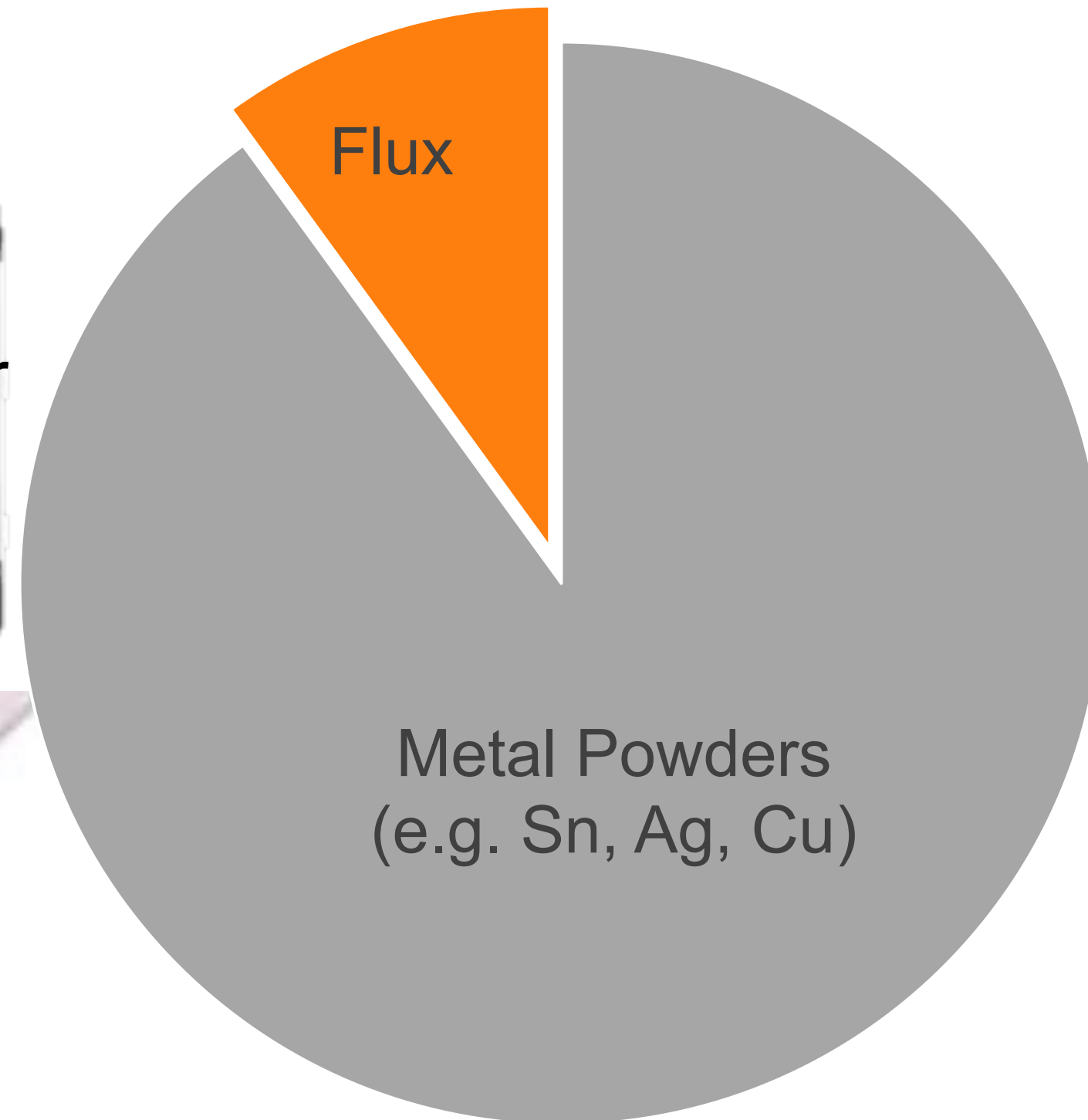
Pre-Test

Post-Test

Solder Chemistry 101



Solder Composition by Weight

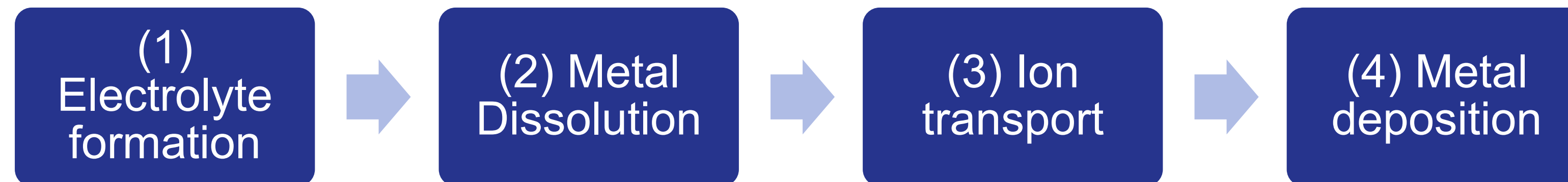
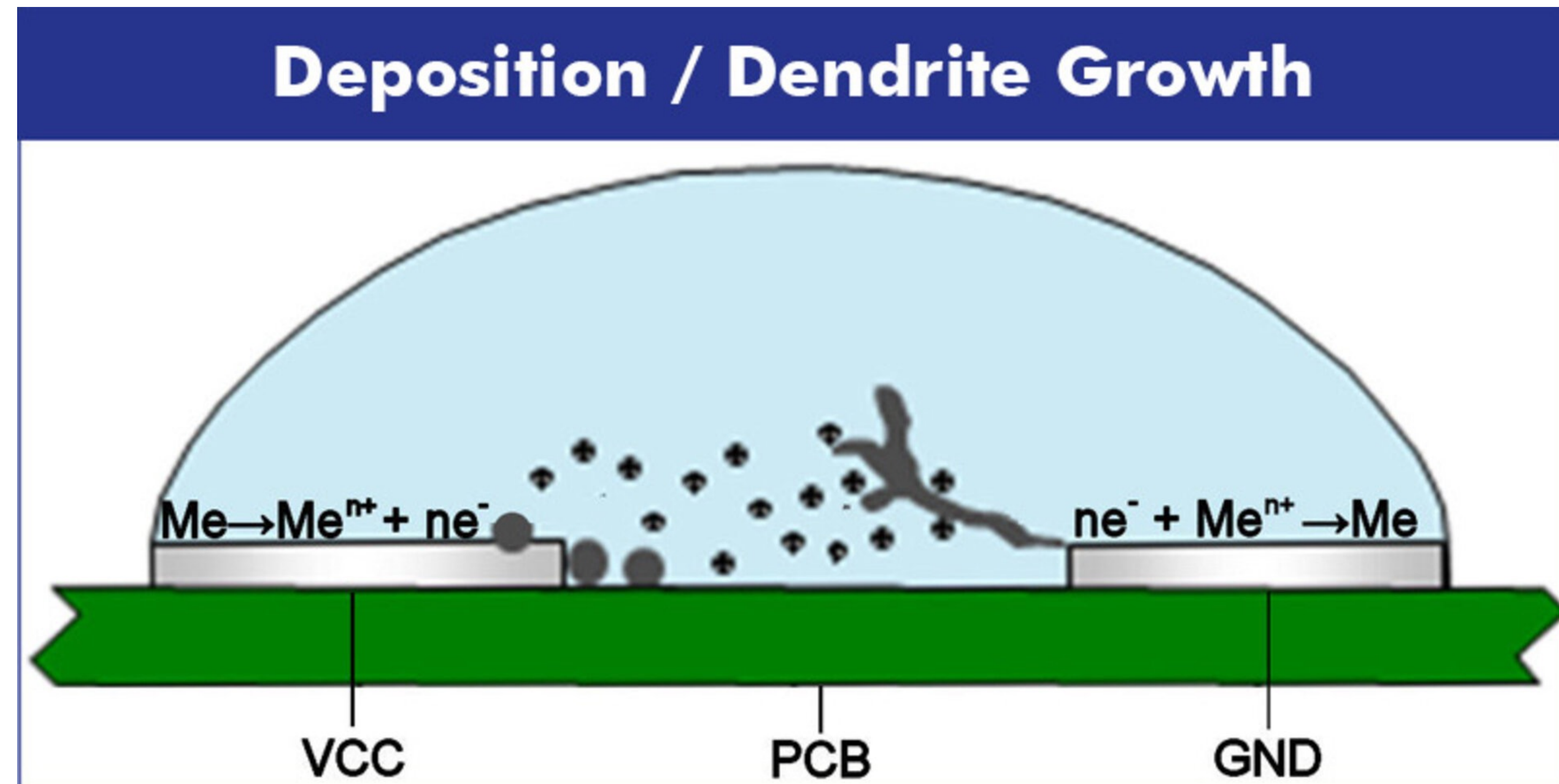


- Rich history of chemistries used over time (e.g. SMT, RoHS, No-clean)
- Metal chemistry informed by assembly & usage (e.g. wave reflow, thermal fatigue)
- Biggest concern for operational shorts is activator!



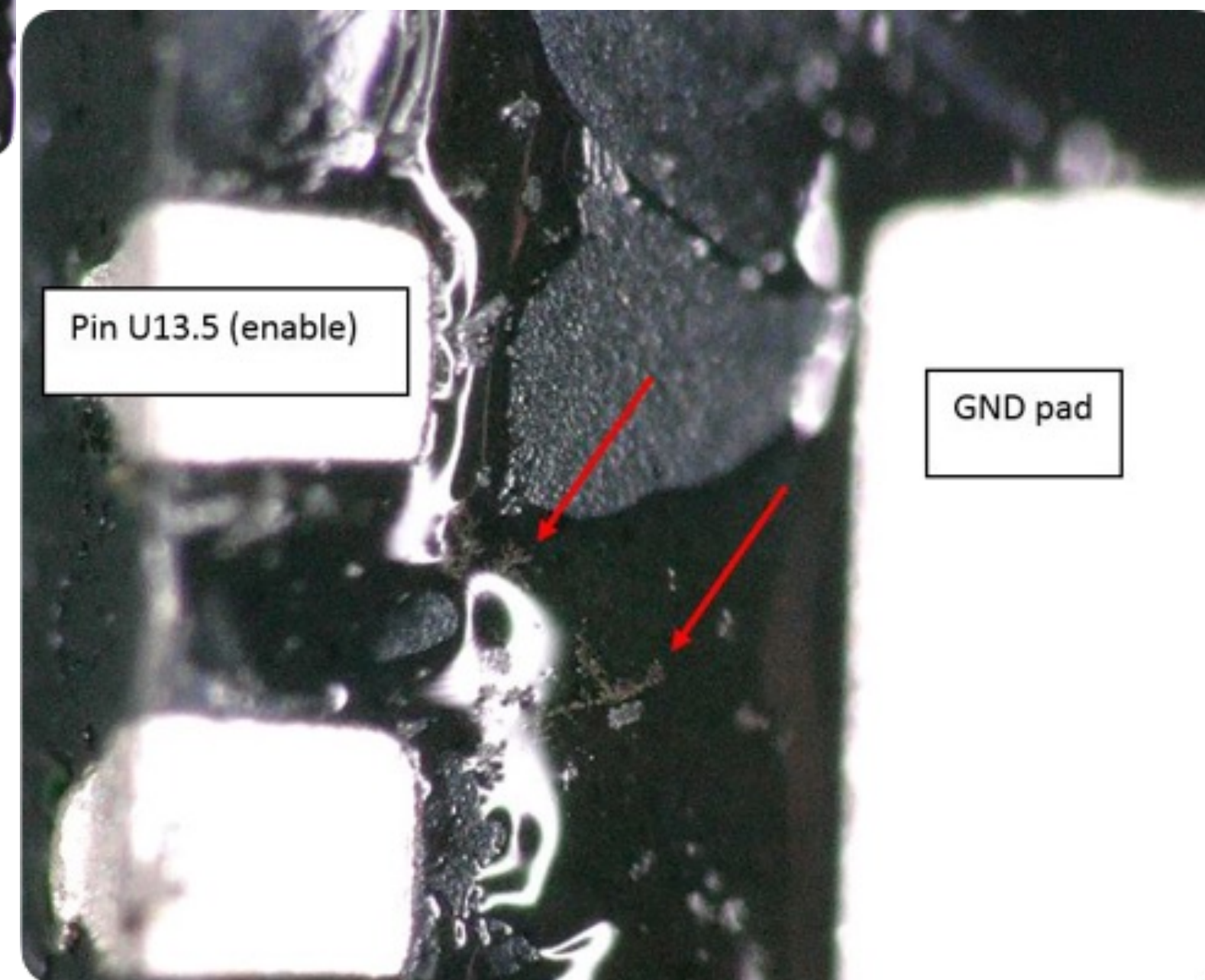
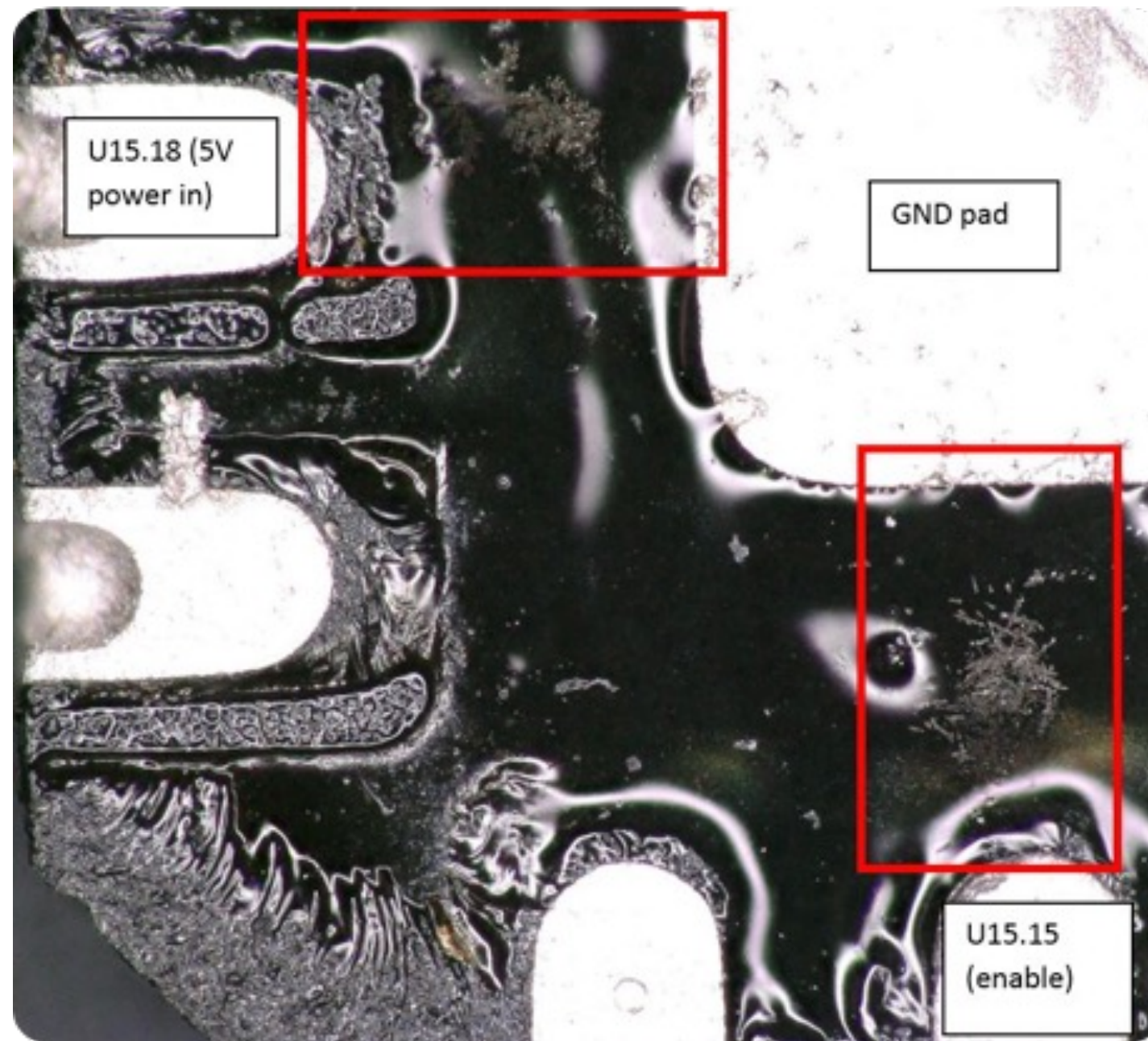
Electrochemical Migration (ECM)

- Process requires ionic medium (flux residue, surface condensation, etc.)
- Weak organic acids & halides often play role in completing the electrochemical circuit



Four-Step ECM Process

How Can We Prevent This?



Options to Remediate

- Washing
- Bake Cycle (deactivation)
- Conformal coat
- Underfill
- Chemistry change
- Design (pad spacing)

Increasing Change

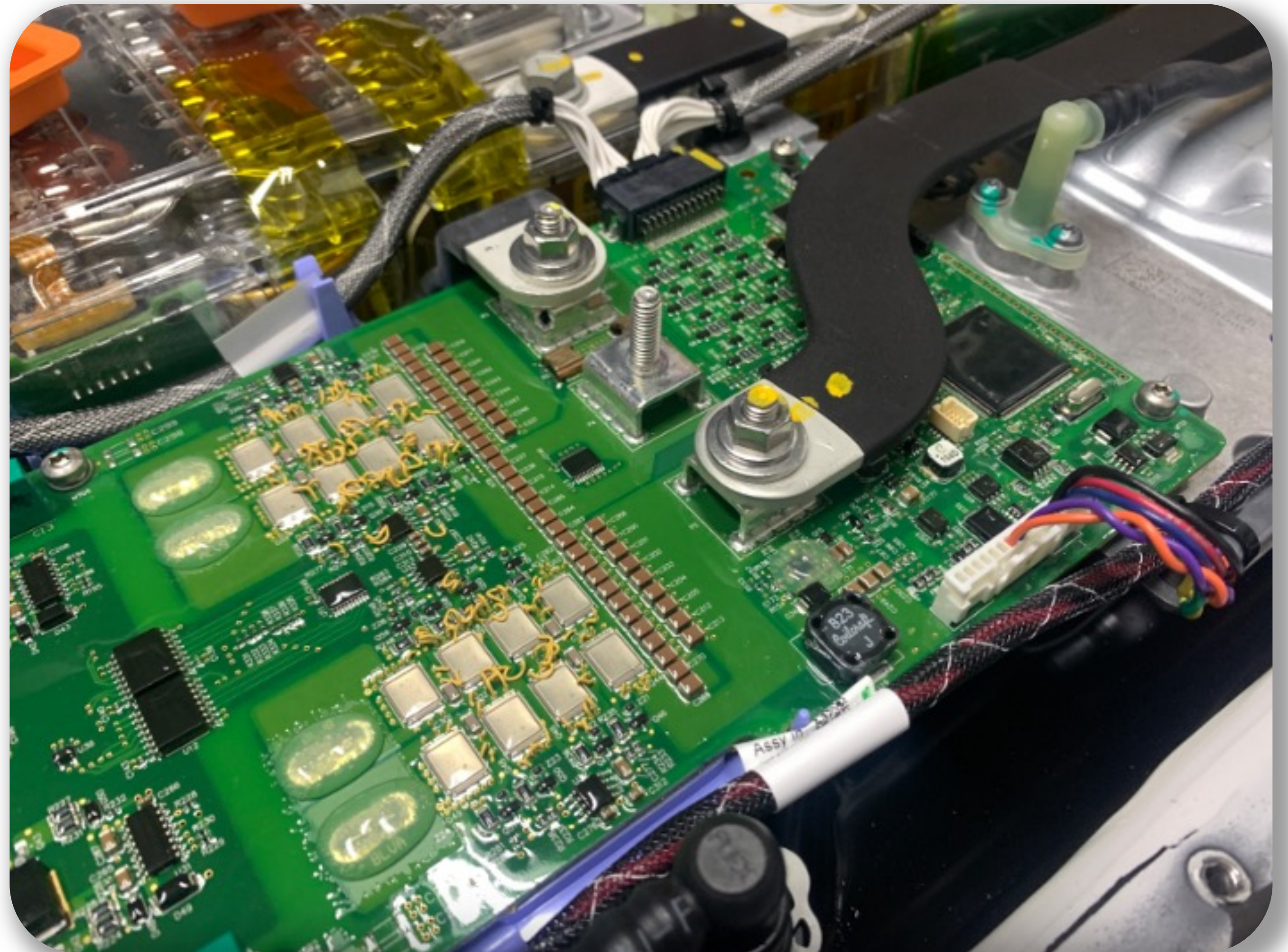
Change → Risk



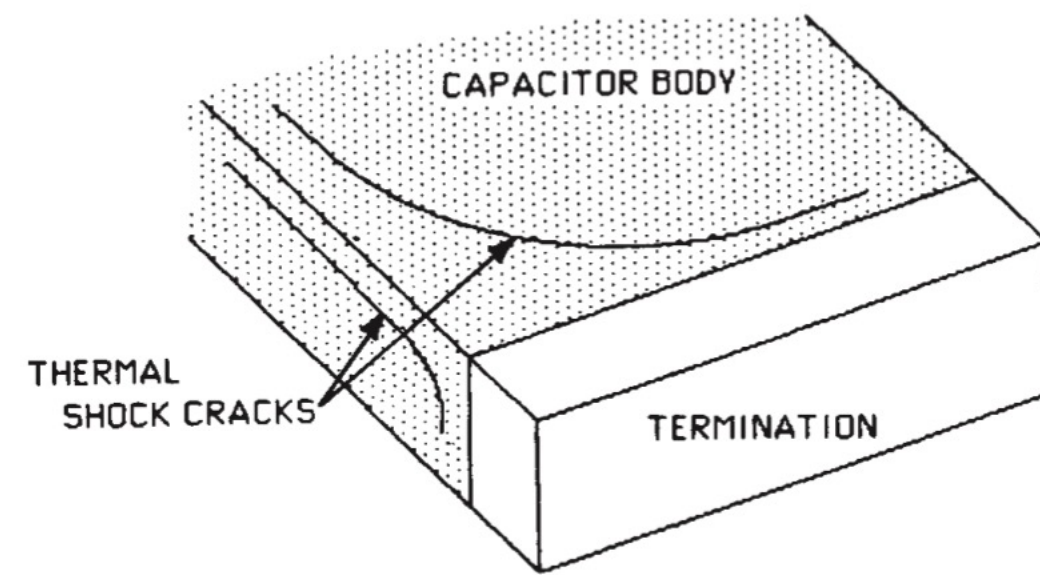
Forensics Flex

Case Background

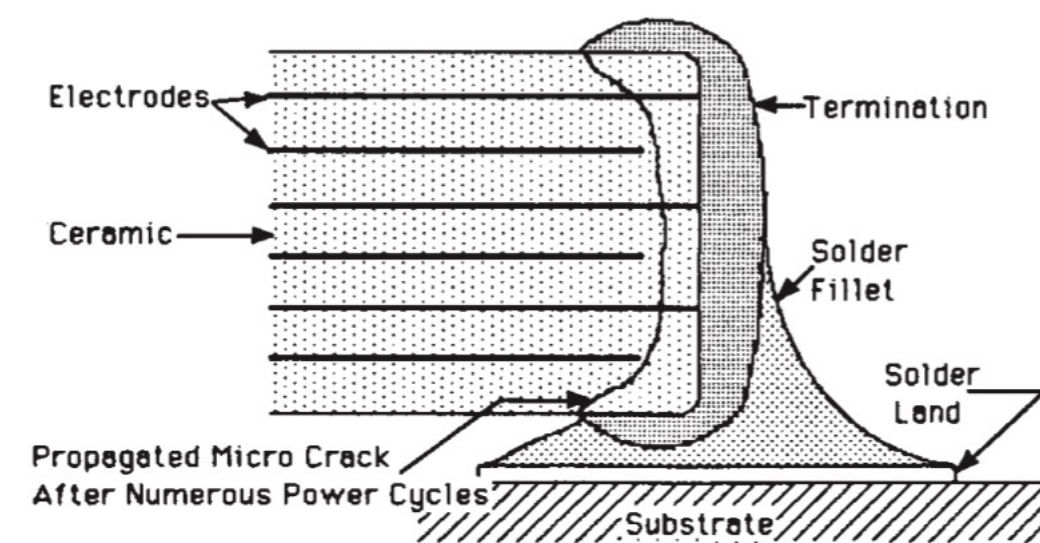
- Multiple units failing at install, isolated to Power Conversion System
- Failed units showed persistent low-voltage shorts around the power takeoff busbars
- Root cause determined to be mechanically shorted MLCCs (multi-layered ceramic caps)



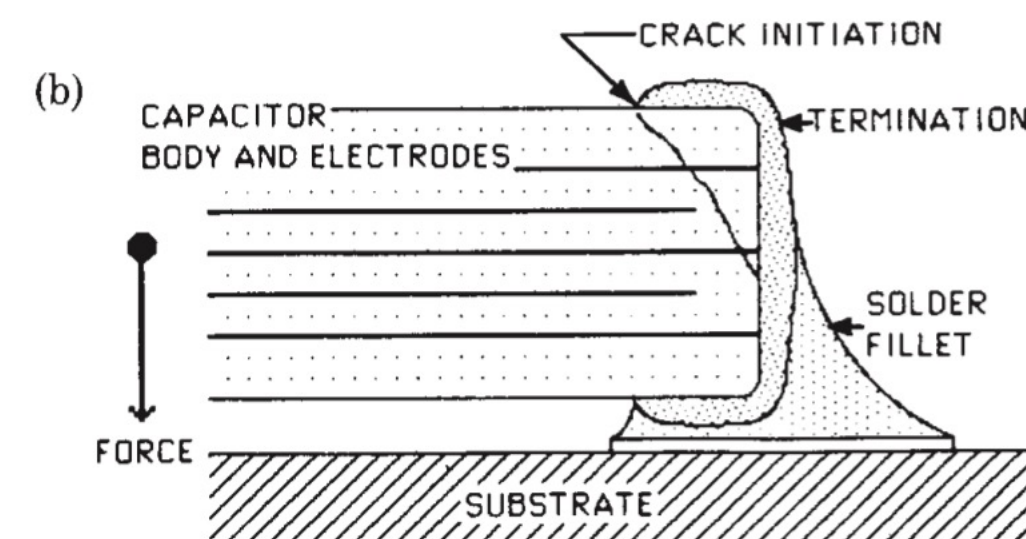
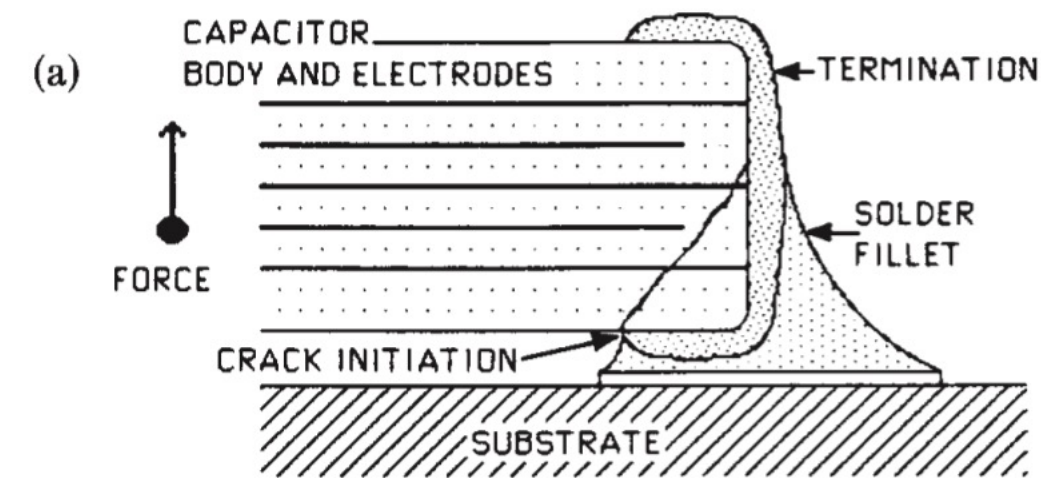
Many Ways to Fail



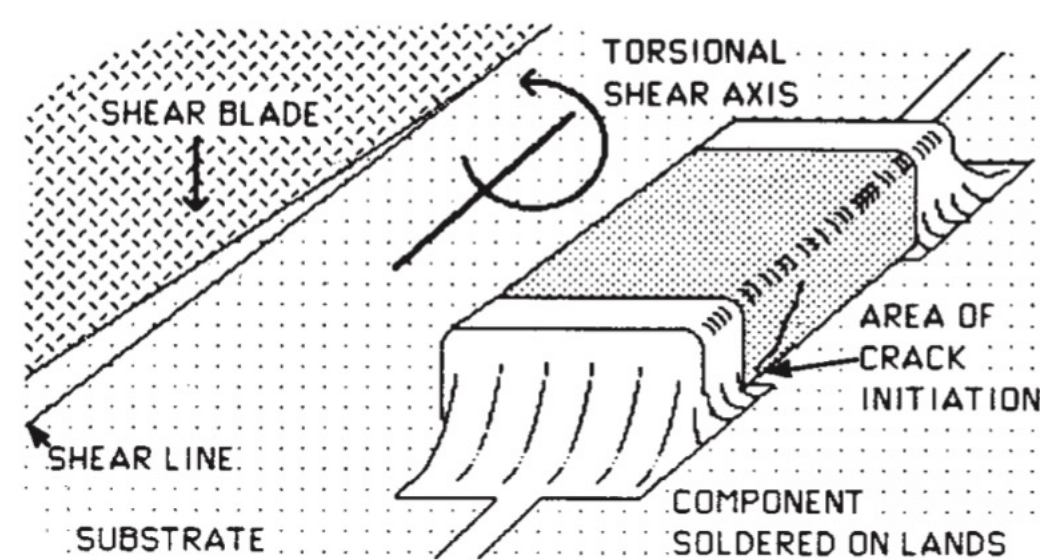
Thermal Shock Cracks



Micro-crack Power Cycle Cracking

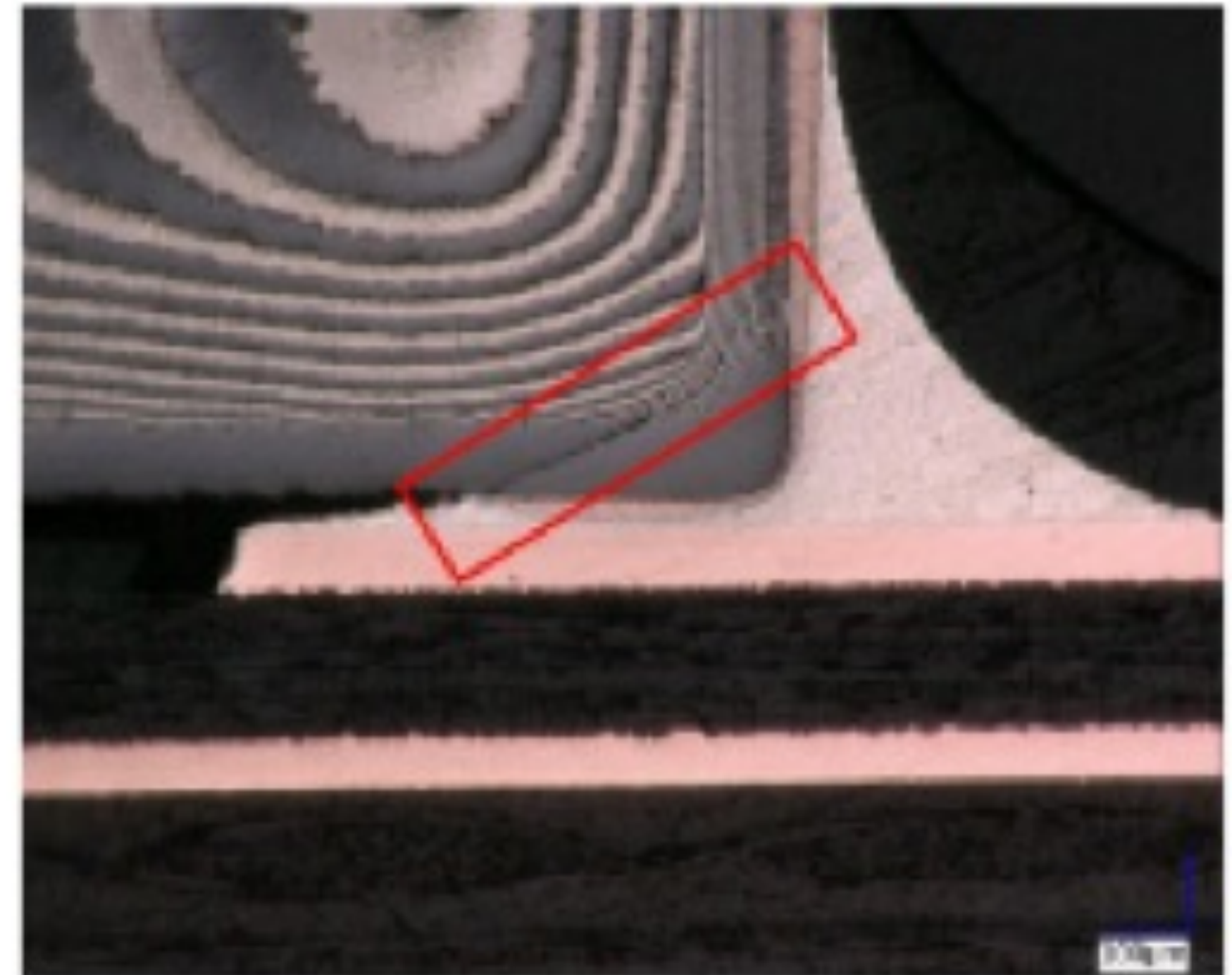


Board Flex Cracks

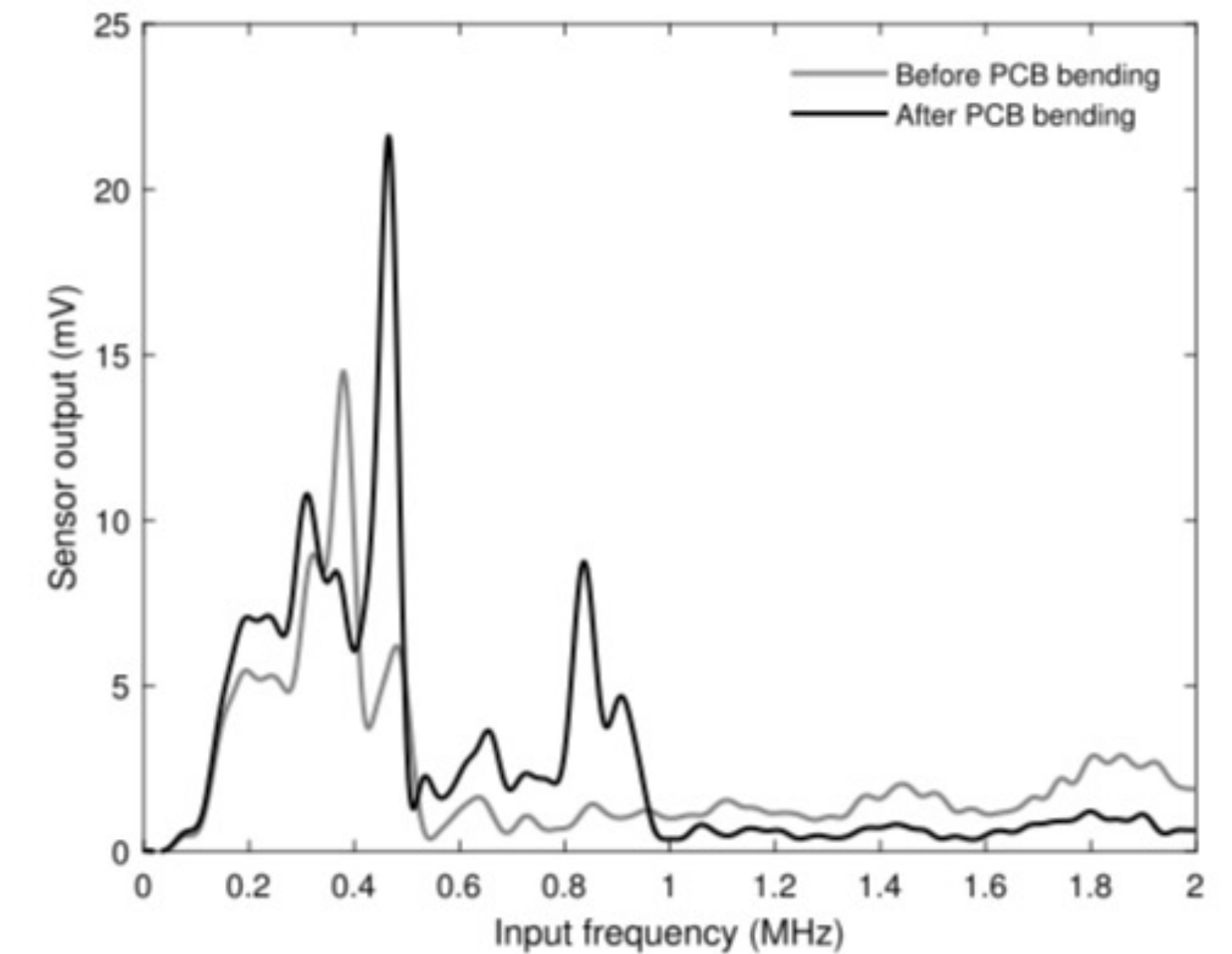
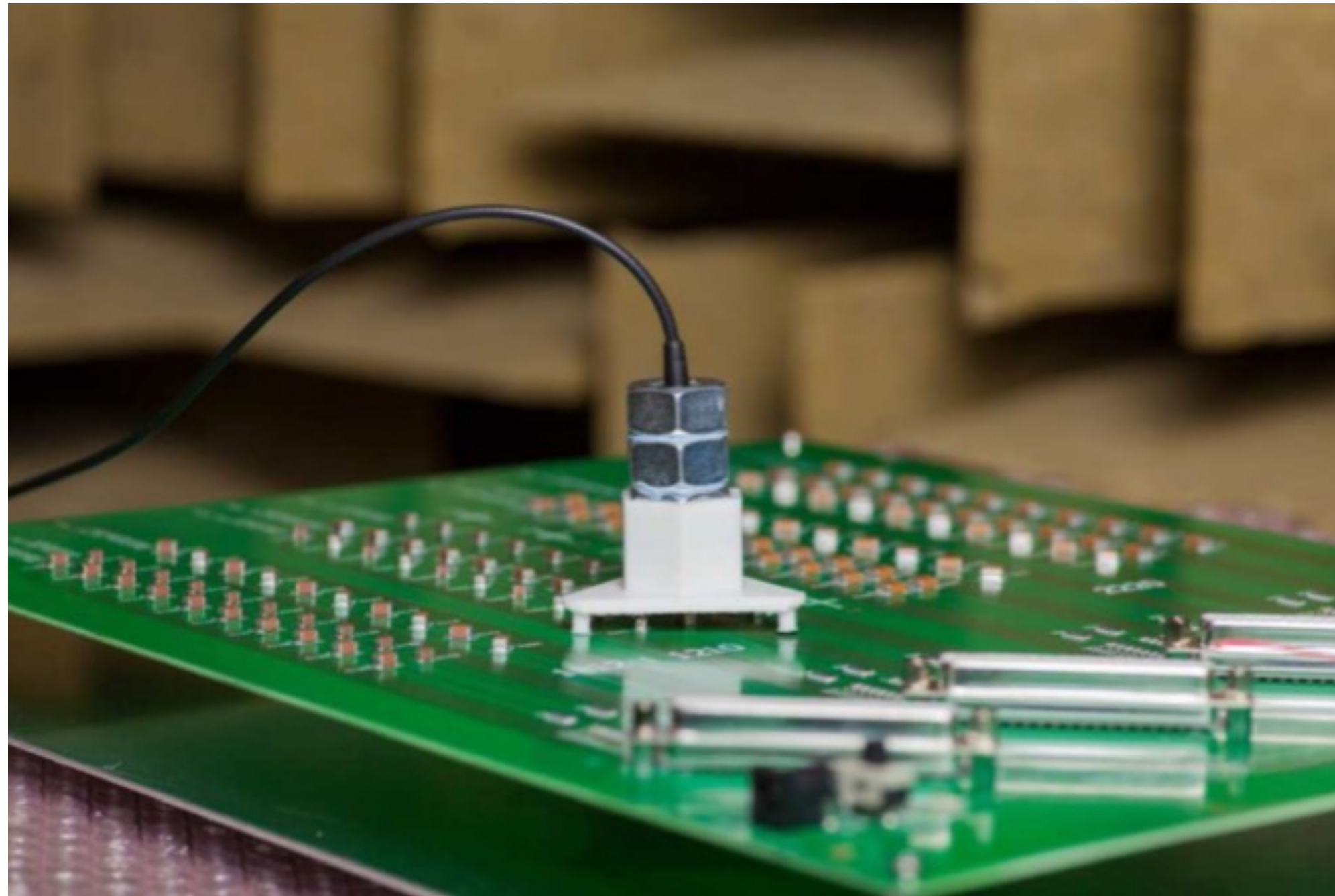


Board Torsion Cracks

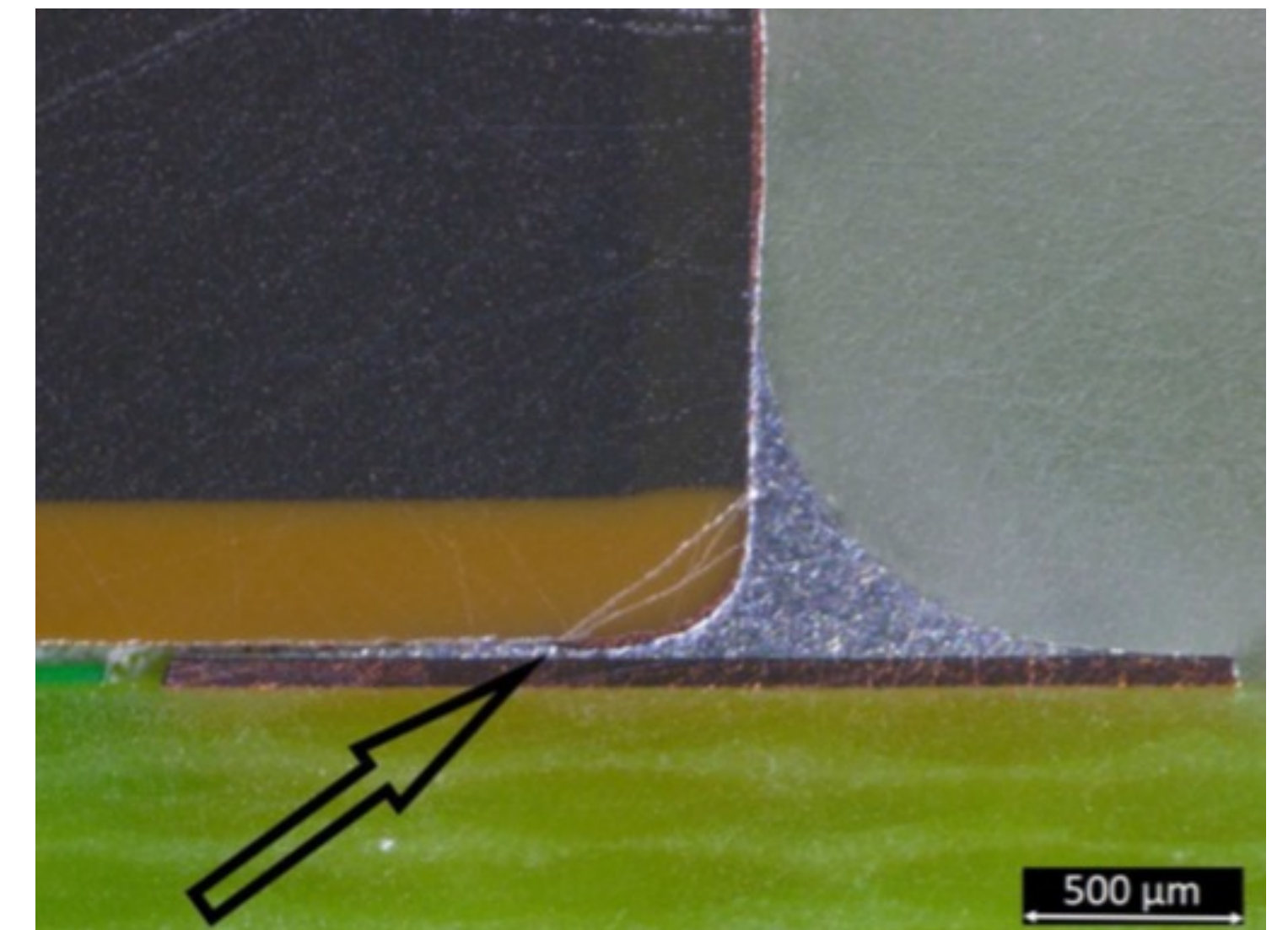
Cross-section of capacitor



Scanning Acoustic Microscopy – Isolate the Failure



Type	Pulse wave
Duration	100 ms
Frequency range	100 Hz ... 2 MHz
Voltage	-10 V ... + 10 V
Duty cycle	80%
Frequency slope	linear



Preempt the Failure – Test to Known Standards

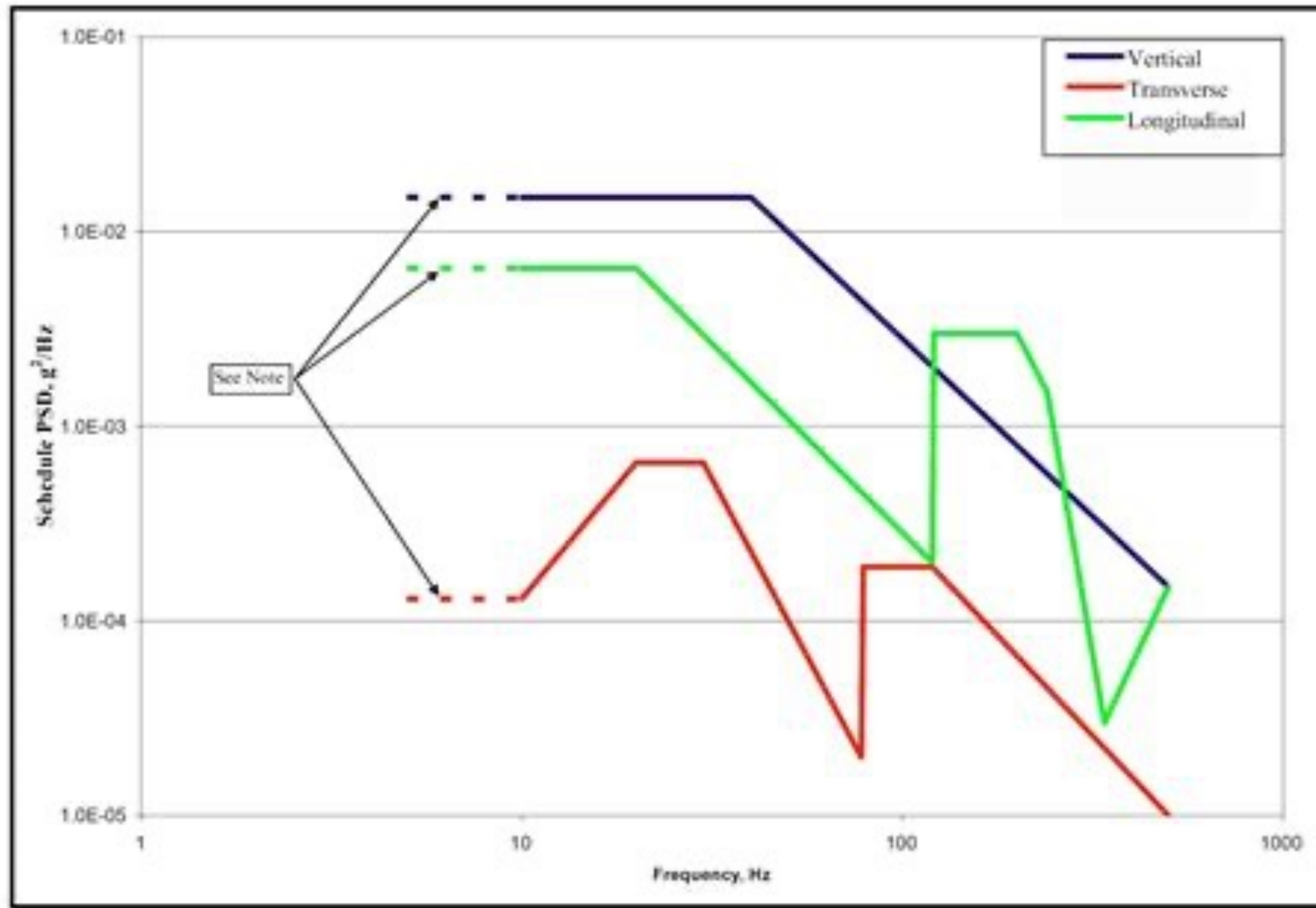
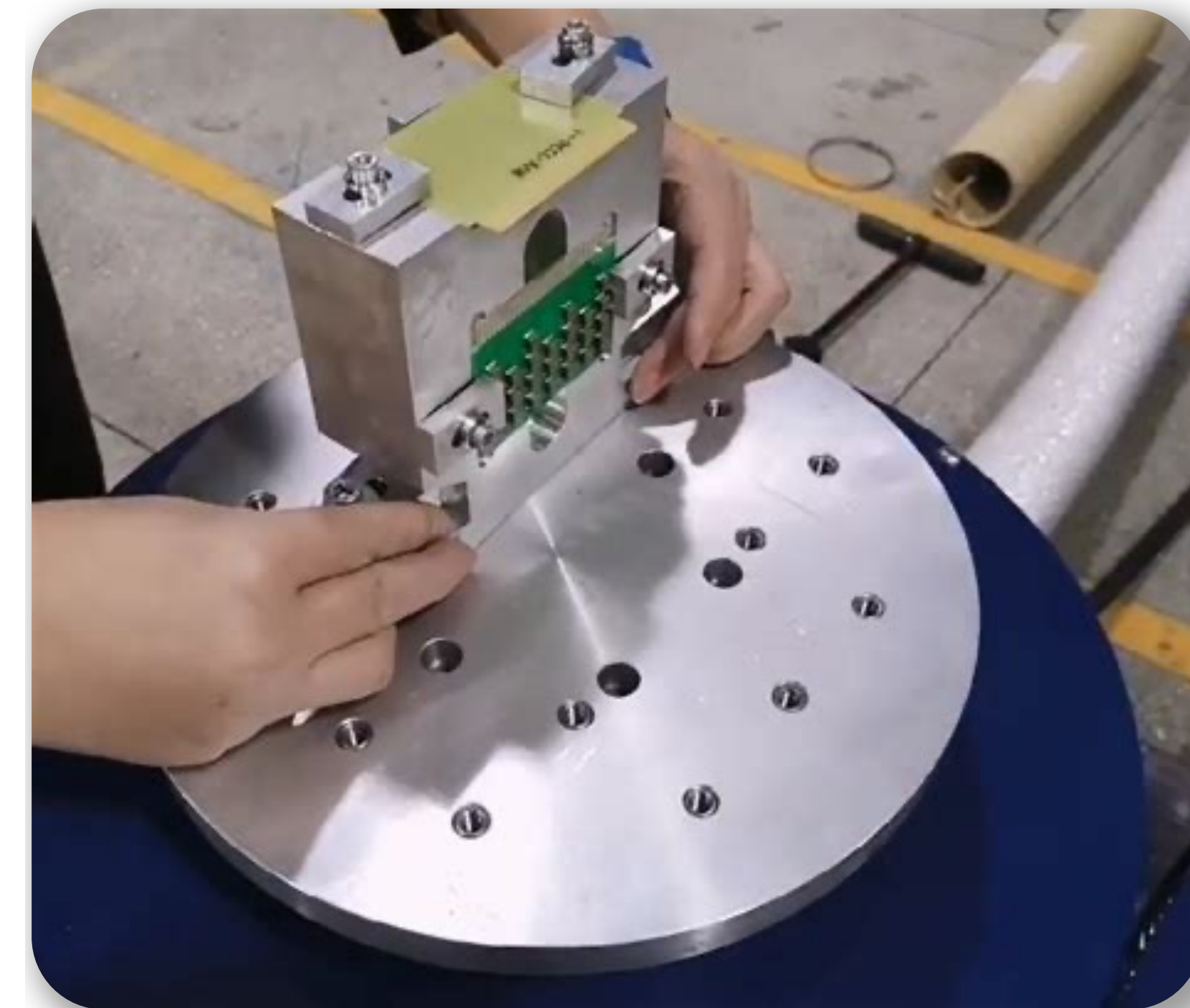
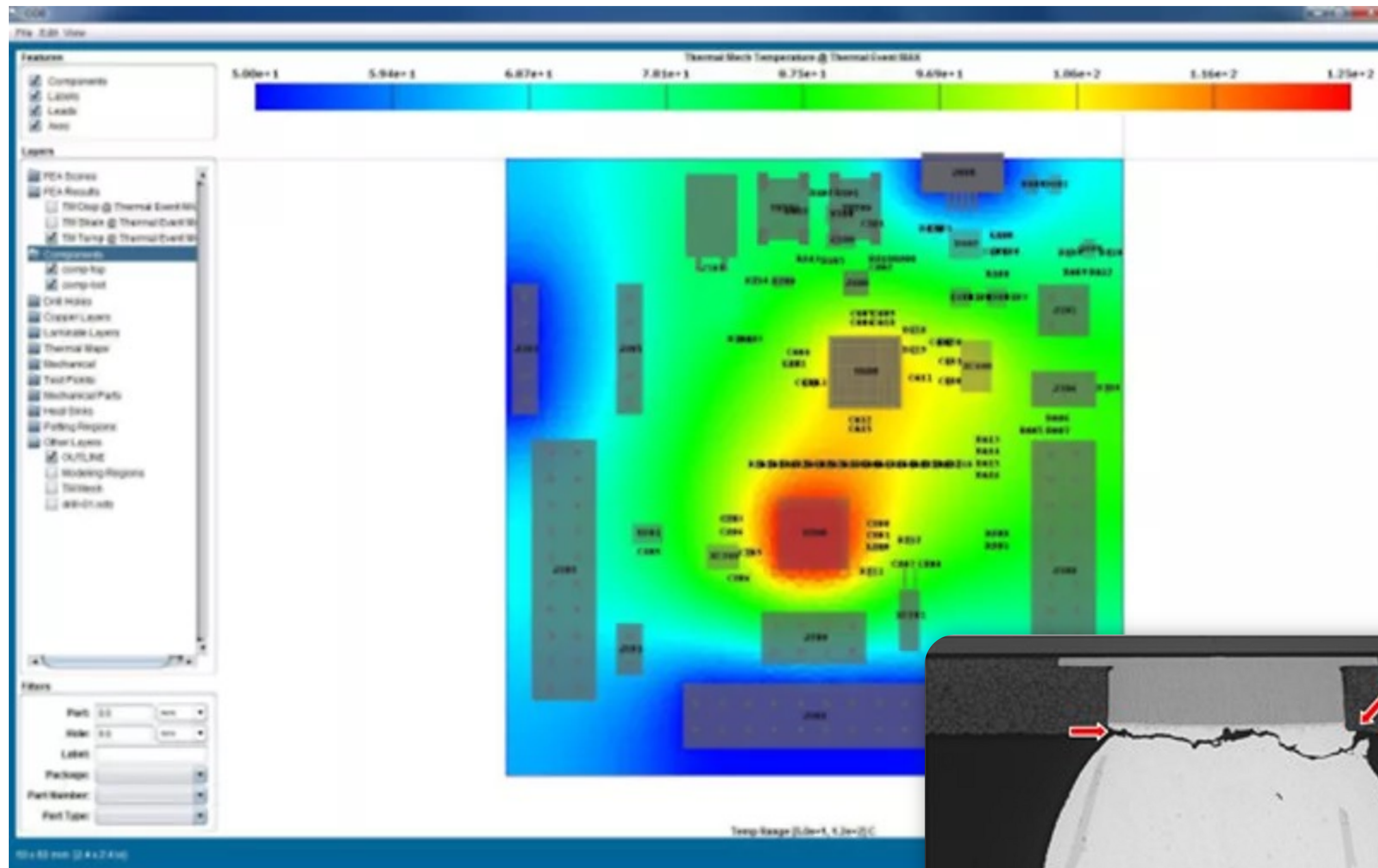


Figure 514.6C-1 – Category 4 - Common carrier (US highway truck vibration exposure).



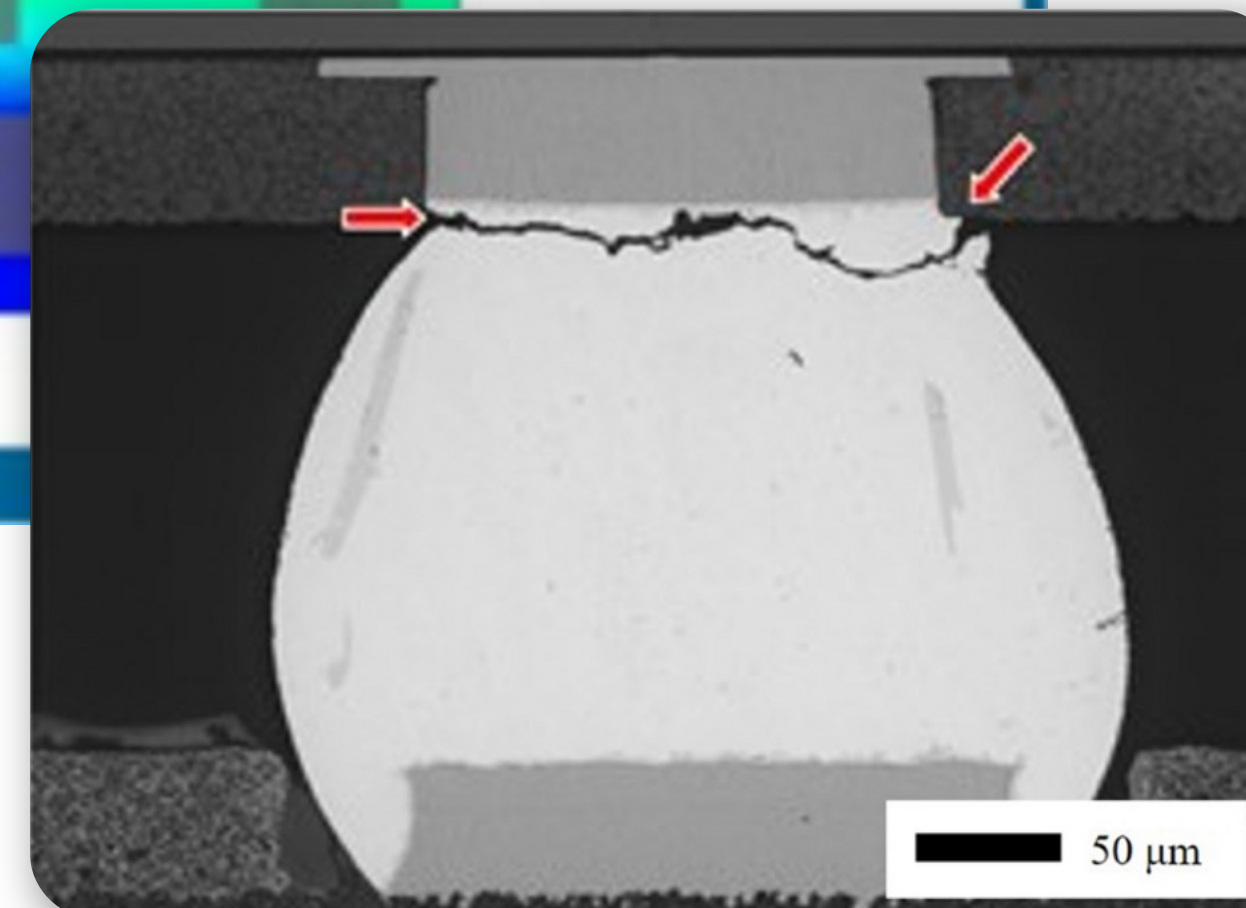
Typical Random Vibration

Predicting Failures with Physics

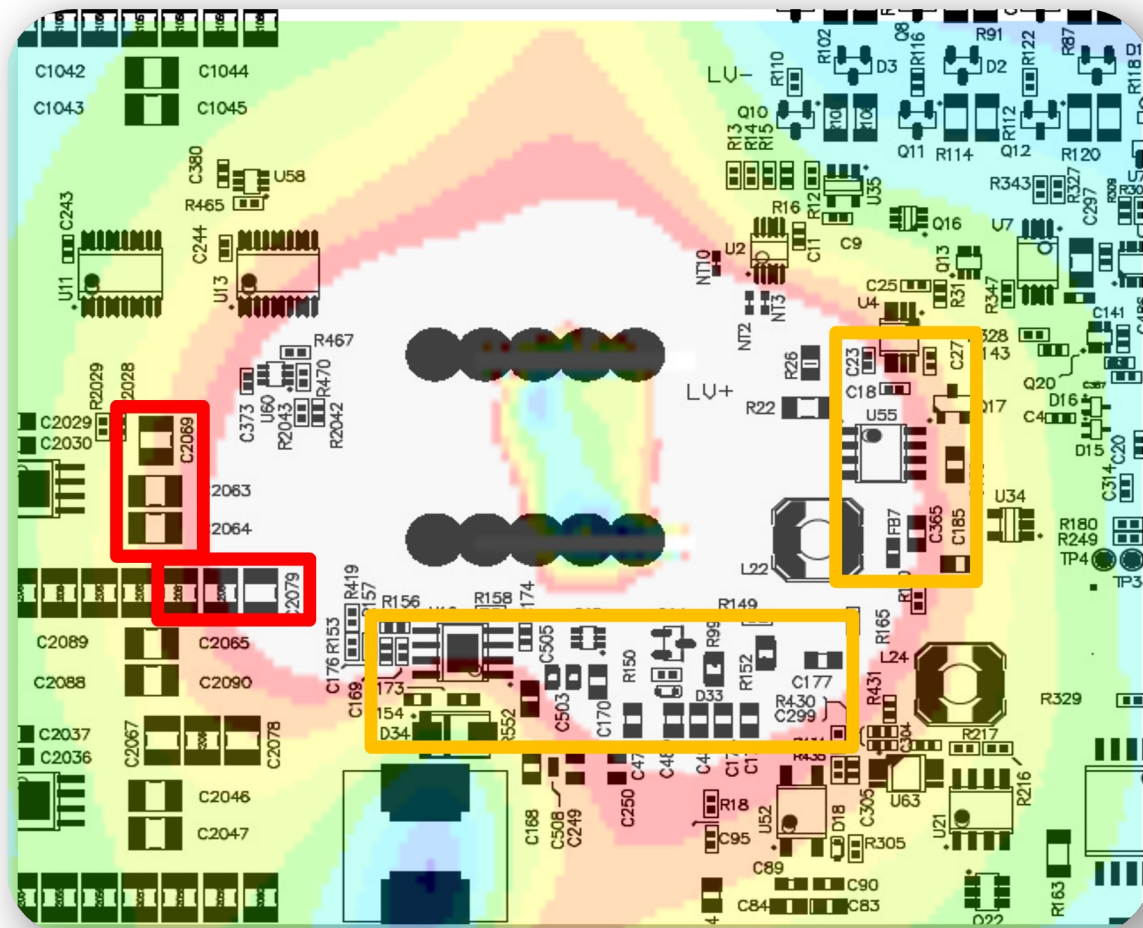


Ansys Sherlock DfR

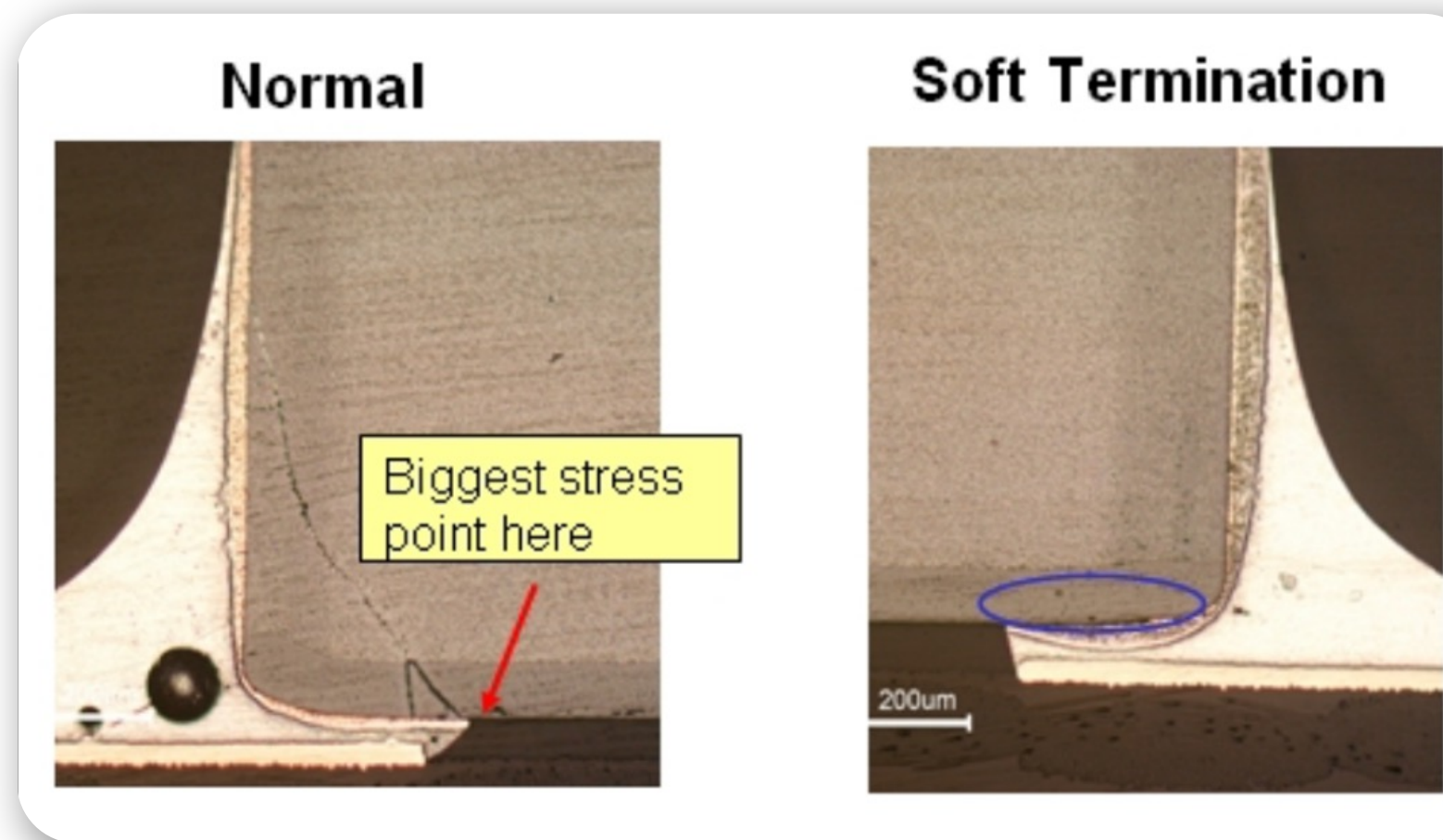
- Stress Concentrators
- Thermal Management
- Minimizing Harmonics
- Solder Joint Fatigue



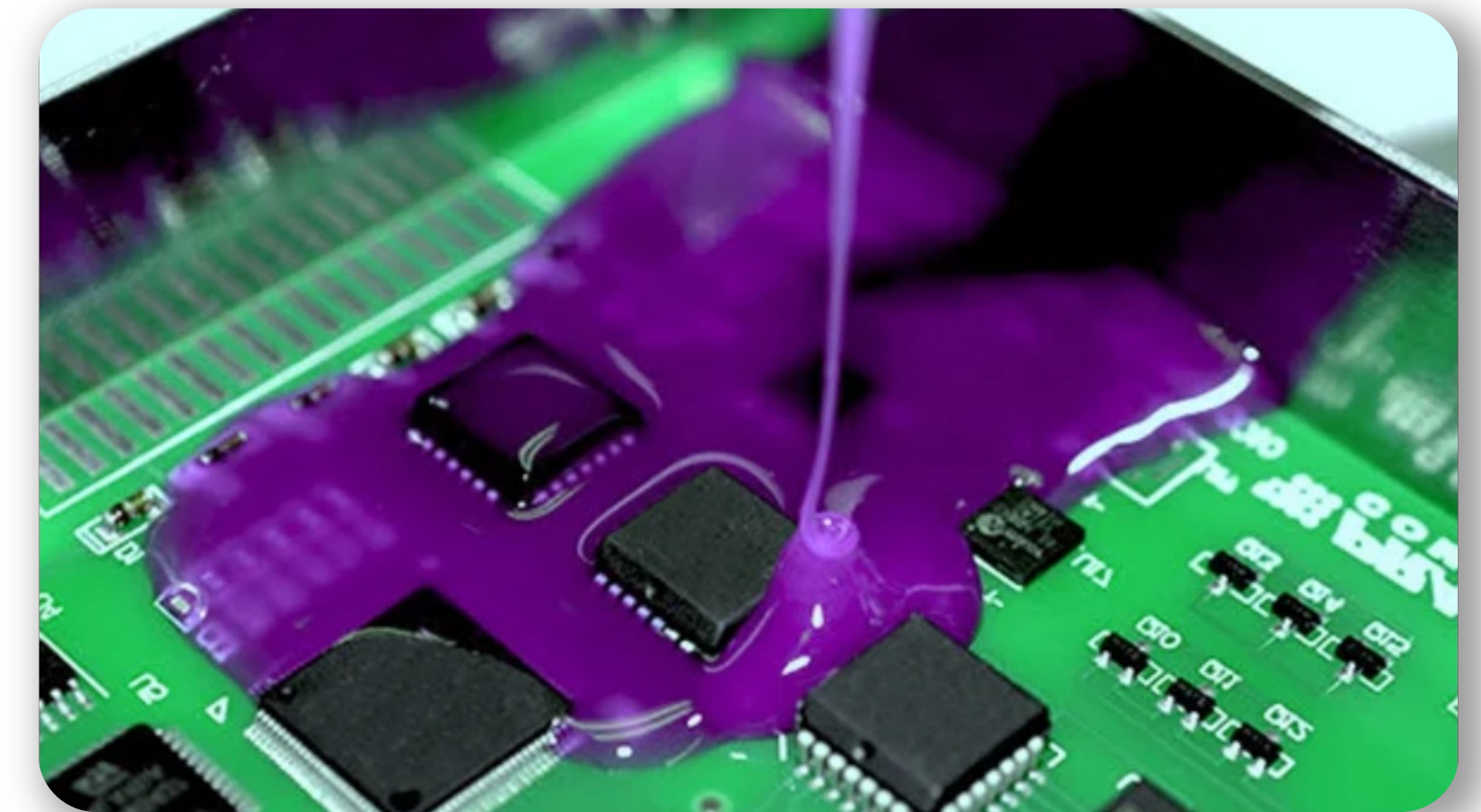
Preventing Reoccurrence



Board Layout / Depop



Soft Termination

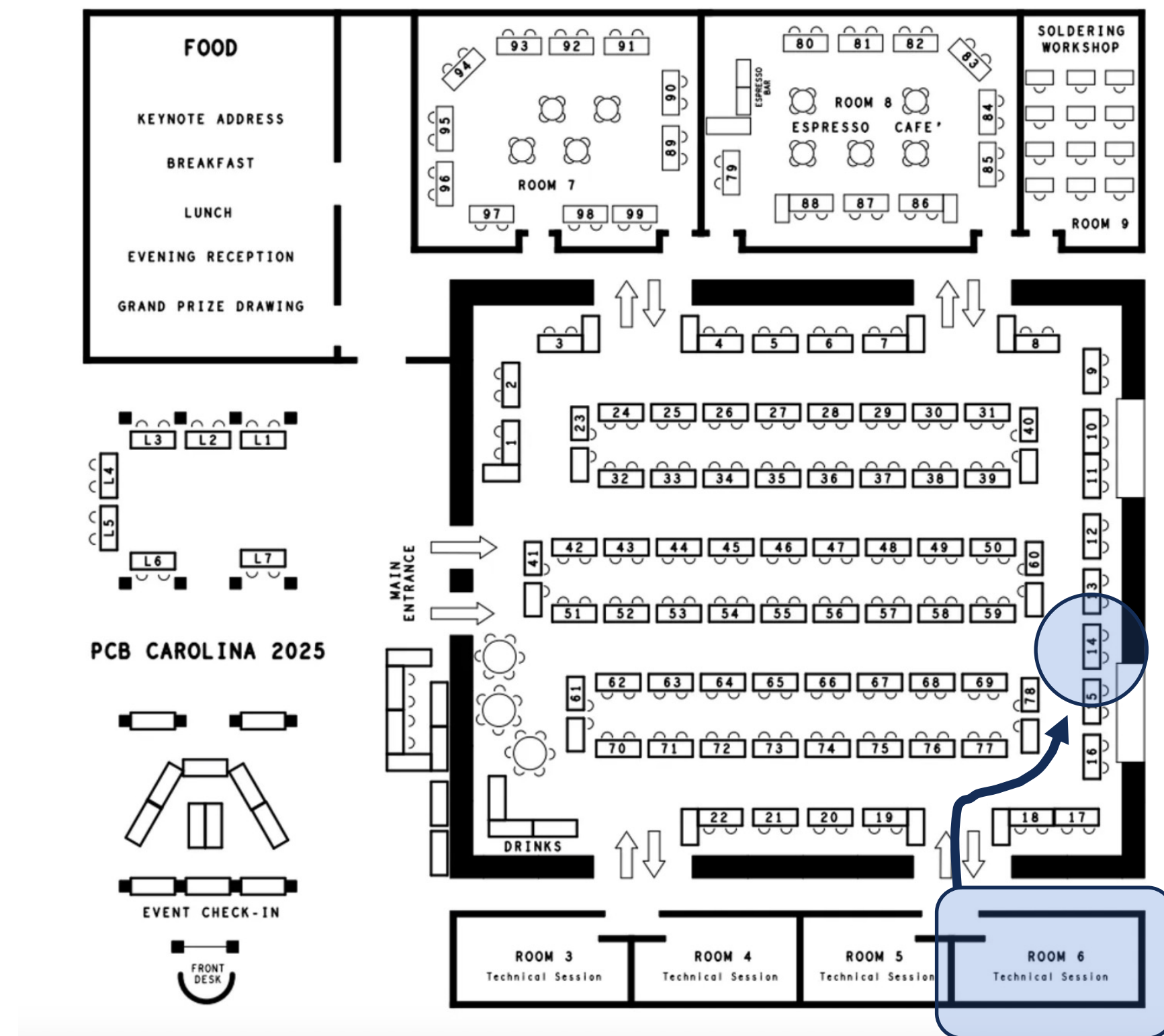


Encapsulation

Options to Remediate

- Electrical Design (Depop)
- Board Layout
- Soft-termination
- Conformal/ Encapsulation

Facing Your Failures



ARA Labs – Table 14 in Main Concourse



CT Orientation →

Find the defect & win a prize!

