Destructive Physical Analysis (DPA) of Electronic Components:

A Primer On MIL-STD-1580 "DPA for EEE Parts"

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Acronyms

Abbreviation	Definition	Abbreviation	Definition
%v	Percent volume	N2	Nitrogen
Ag	Silver	NASA	National Aeronautics and Space Administration
Al	Aluminum	NH3	Ammonia
Ar	Argon	O2	Oxygen
Au	Gold	PED	Plastic Encapsulated Diode
CA	Construction Analysis	PEM	Plastic Encapsulated Microcircuit
CO	Carbon monoxide	PET	Plastic Encapsulated Transistor
CO2	Carbon dioxide	PIND	Particle Impact Noise Detection
Cu	Copper	PMA	Prohibited Materials Analysis
DPA	Destructive Physical Analysis	PMPCB	Parts, Materiel, and Processes Control Board
EDS	Energy Dispersive Spectroscopy	PN	Part Number
EEE	Electrical, Electronic, and Electromechanical parts	Ppm	Parts per million
EEEE	Electrical, Electronic, Electromechanical, and Electro-optical parts	ppmv	Parts per million volume
FA	Failure Analysis	QML	Qualified Manufacturer List
FC	Fluorocarbons	QPL	Qualified Part Listing
GSFC	Goddard Space Flight Center	SAM	Scanning Acoustic Microscopy
He	Helium	SEM	Scanning Electron Microscope
IC	Integrated Circuit	Si	Silicon
IGA	Internal Gas Analysis	SMD	Surface mount device
IR	Infrared	SnPb	Tin lead
JFET	Junction Field Effect Transistor	TM	Test Method
Kr85	Krypton 85	um	Micrometer
MIL-STD	Military Standard	UV	Ultraviolet
		XRF	X-Ray Fluorescence

Overview

- Since 1980 MIL-STD-1580 “Destructive Physical Analysis (DPA) for Electronic, Electromechanical, and Electromagnetic Parts” has provided the framework for the performance of DPA for all major categories of EEE parts (e.g., capacitors, resistors, discrete semiconductors, ICs, hybrids, relays and more).

- This presentation provides an overview of DPA to assess the quality of individual production lots of EEE components intended for use in high reliability (e.g., aerospace and defense) applications.

- Emphasis will be on the applicability of MIL-STD-1580, purpose, techniques/methods and will include several DPA examples.

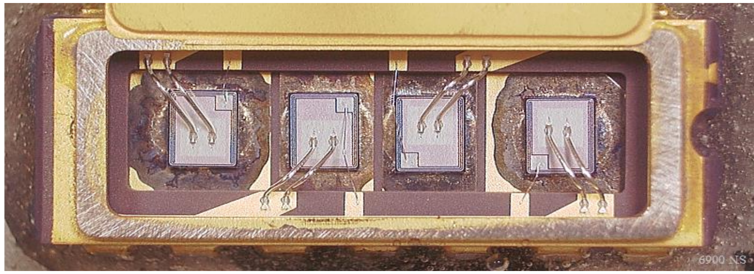
What DPA Is and What it is Not

Destructive Physical Analysis (DPA)

- Verify internal design, materials, construction, and workmanship
- Preclude installation of parts from lots having patent or latent defects
- Aid in dispositioning lots that exhibit anomalies
- Evaluate supplier production trends
- Assist in counterfeit part investigations
- Identify changes in design, materials, or processes

What Destructive Physical Analysis (DPA) does not cover

- Failure Analysis (FA)
  - FA is the process of examining data and physical evidence related to EEEE part failure to meet its intended function
- Construction Analysis (CA)
  - CA is the process of examining EEEE part construction to understand its design, materials, and identify flaws that may lead to failures during use
  - CA is a term more generic than DPA, where additional steps may be recommended that are not covered by DPA specs
  - There are no clearly defined criteria for determining pass/fail of anomalies, and they must be dispositioned by cognizant engineers
- Root Cause Analysis
  - Identification of processes and events that led to a failure with the intent of mitigating future failures
  - Failure analysis and destructive physical analysis can be a part of root cause analysis



Destructive Physical Analysis

Image Source: NASA GSFC

Failure Analysis

Image Source: NASA GSFC

DPA References

- **MIL-STD-1580 "Destructive Physical Analysis For Electronic, Electromagnetic, And Electromechanical Parts"**
  https://landandmaritimeapps.dla.mil/Programs/MilSpec/ListDocs.aspx?BasicDoc=MIL-STD-1580

  - **MIL-STD-202 "Test Method Standard Electronic And Electrical Component Parts"**
    https://landandmaritimeapps.dla.mil/Programs/MilSpec/ListDocs.aspx?BasicDoc=MIL-STD-202

  - **MIL-STD-750 "Test Methods For Semiconductor Devices"**
    https://landandmaritimeapps.dla.mil/Programs/MilSpec/ListDocs.aspx?BasicDoc=MIL-STD-750

  - **MIL-STD-883 "Test Method Standard Microcircuits"**
    https://landandmaritimeapps.dla.mil/Programs/MilSpec/ListDocs.aspx?BasicDoc=MIL-STD-883

- **NASA S-311-M-70 REFERENCED BY PEM-INST-001. most requirements refer to Mil-Std-1580 https://nepp.nasa.gov/files/26590/S-311-M-70D.pdf**

- **MSFC-STD-3012 (most requirements refer to MIL-STD-1580):**
  https://nepp.nasa.gov/nepag/guidelines/MSFC-STD-3012A.pdf

- **SSQ 25000 Rev D (Space Station) (most requirements refer to MIL-STD-1580)**

- **ESCC Basic Specification No. 21001 (European standard):**
  https://escies.org/download/specdraftapppub?id=4617

DPA Sample Size per MIL-STD-1580

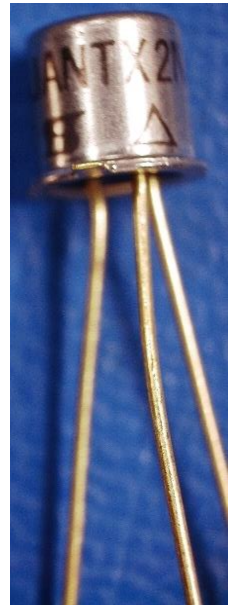
- Minimum sample size shall be two (2) percent or five (5) units, whichever is greater, to a maximum of 30 units per Lot Date Code and Part Number combination
- It is recommended to double the sample size for non-QPL/QML devices
- In case of high-cost parts, parts with very limited availability, or parts manufactured on a controlled QPL/QML product line the sample size may be reduced with the approval of Parts, Materiel, and Processes Control Board (PMPCB) or as defined by project or program requirements

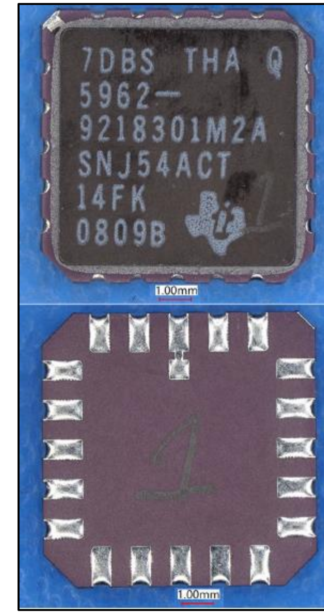
Most common sample size is 1 to 5 depending on part cost

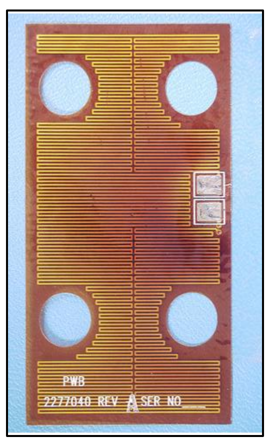
EEE COMMODITIES COVERED BY 1580

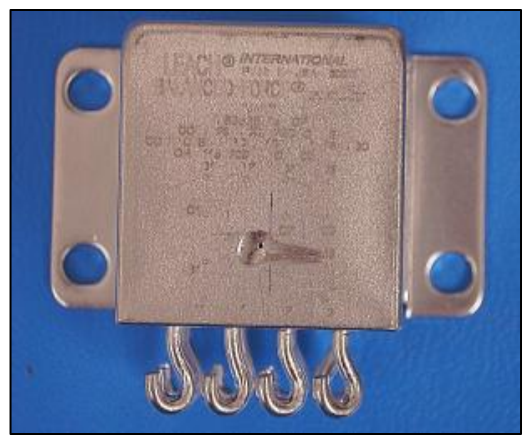
Chapter	Commodity	Chapter	Commodity
10	Capacitors	18	Resistors
11	Connectors	19	Switches
12	Quartz Crystals	20	Thermistors
13	Diodes	21	Transistors
14	Feed-Through Filters	22	RF Devices
15	Magnetic Devices	23	Fuses
16	Microcircuits	24	Heaters
17	Relays		

EEE Commodity Examples (External Photos)








Images Source: NASA GSFC

Basic DPA Flow of Tests

Non-Destructive Testing

- External Visual Inspection/Configuration
- Real time X-Ray
- XRF/Prohibited Material Inspection
- Particle Impact Noise Detection (PIND)
- Hermetic Seal Testing
- Acoustic Microscopy
- Electrical Testing (selectively used)

Destructive Testing

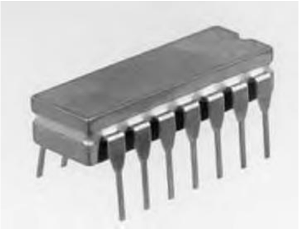
- Internal Gas Analysis (IGA)
- Mechanical/Chemical De-encapsulation
- Laser Ablation
- Internal Visual Inspection
- Bond Pull Testing
- Ball Shear Testing
- Die Shear Testing
- SEM Metallization Inspection
- Cross Section
- Scribe and Break (glass body diodes only)

Commodity Packaging

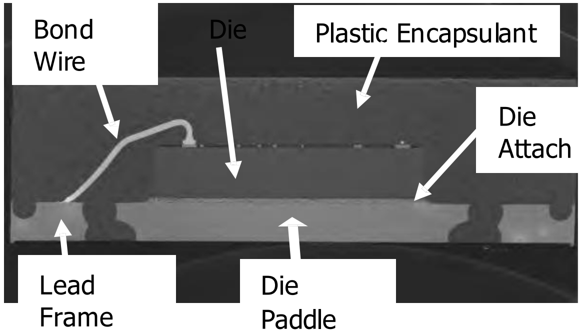
Hermetic and non-hermetic (plastic) packages are the most common type of packages.

- Hermetic packages
  - Typically made of metal, ceramic, glass, or combinations thereof.
  - Most commonly used for environmental protection.
- Non-hermetic (plastic) packages
  - Use organic materials for environmental protection.
  - Plastics are transfer molded or used as coating.
  - Several advantages are cost, size and weight reduction.
  - Plastic encapsulated IC's or Microcircuits are commonly referred to as, PEMs. Plastic encapsulated Transistors and Diodes are typically referenced as PETs and PEDs, respectively.

Hermetic Package Example
Image Source: Integra Tech



Hermetic Package Example
Image Source: Integra Tech



Non-hermetic (plastic) package example in cross-section
Image Source: Integra Tech

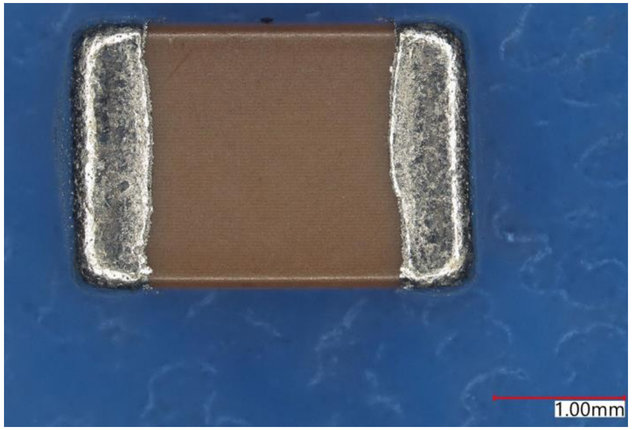
External Visual

Common Test Methods:

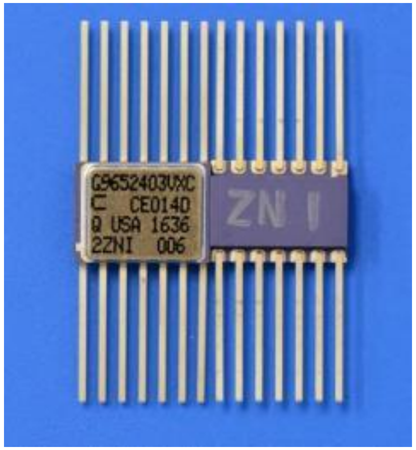
- MIL-STD-750 TM 2071
- MIL-STD-883 TM 2009

The markings and the devices for DPA are optically documented. The devices are checked for configuration compliance against the device datasheet/drawing, and inspected for any external defects that may affect reliability in accordance with the detailed requirements and/or applicable MIL-STDs.

This inspection is typically performed with the use of a low-mag microscope.



External Visual if a Ceramic Chip Capacitor
Image Source: NASA GSFC



External Visual if a Hermetic Microcircuit
Image Source: Integra Tech

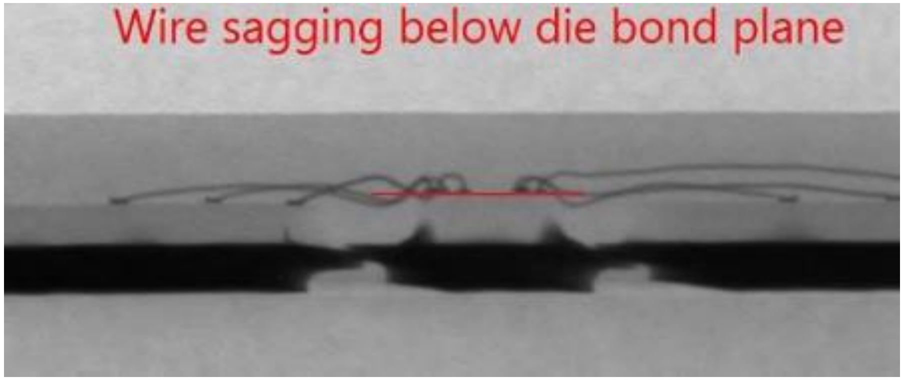
External Visual if a Plastic Encapsulated Microcircuit
Image Source: Integra Tech

X-Radiography

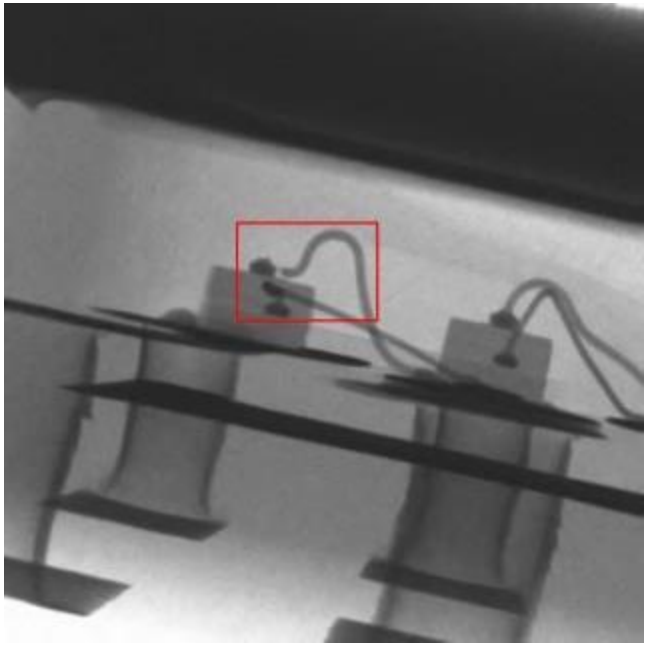
Common Test Methods:
- MIL-STD-750 TM 2076
- MIL-STD-883 TM 2012

Real time X-Ray equipment is a technique used to non-destructively inspect for anomalies and suspect defects of a device.

X-Ray is also used to determine the internal construction before mechanical delid or chemical de-encapsulation to determine internal clearances. It is also useful as an aid in locating cross sectioning cuts.



X-ray of a microcircuit showing sagging wirebonds
Image Source: Integra Tech



X-ray of a microcircuit showing broken wirebond
Image Source: Integra Tech

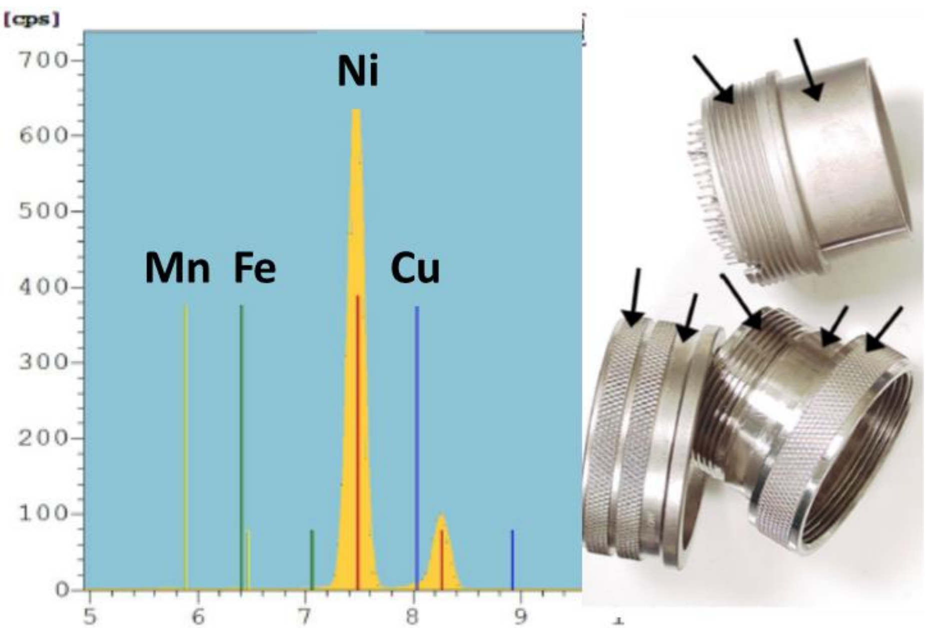
Prohibited Material Analysis (PMA)

Common Test Method:
- MIL-STD-1580 Requirement 9

Prohibited Material Analysis (PMA) of external parts and package materials utilizing X-Ray Fluorescence Spectrometry (XRF) is routinely performed during DPA.

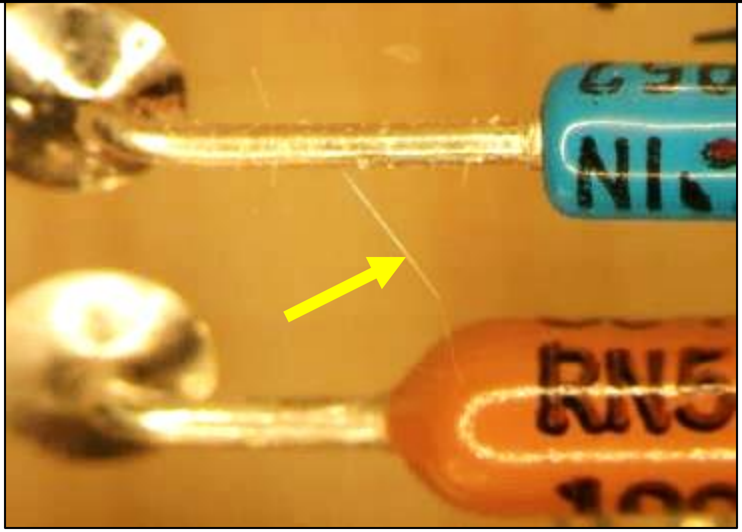
XRF equipment is used to measure the elemental composition of external device features. Scanning Electron Microscopy (SEM) using Energy Dispersive Spectroscopy (EDS) is another technique that can be utilized to determine elemental composition.

The elemental content of alloys and electroplated finishes is analyzed to determine the weight percentage of prohibited materials such as Tin, Cadmium and Zinc.



XRF spectrum of circular connector shell
Image Source: NASA GSFC

Tin Whiskers on Tin-Plated Diode Terminals
https://nepp.nasa.gov/whisker/photos/index.html#diode


Tin Whisker
Image Source: NASA GSFC

Particle Impact Noise Detection (PIND)

Common Test Methods:
- MIL-STD-750 TM 2052
- MIL-STD-883 TM 2020

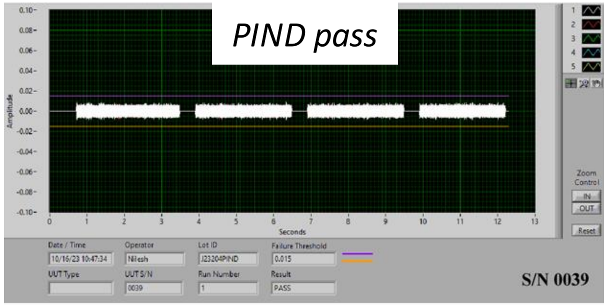
Particle Impact Noise Detection, otherwise referred to as PIND, is performedin order to detect the presence of loose particles inside a device cavity. Loose particles can lead to failures

1. in space, where a stray particle may float in zero-g environment and may settle to short between closely spaced conductors
2. in high vibration and mechanical shock where such actions may induce particles to move within a package increasing likelihood of undesirable consequences (e.g., short circuit for electrically conductive particles or impeding movement of moveable objects in relays or blocking electrical conduct if non-conductive particles)

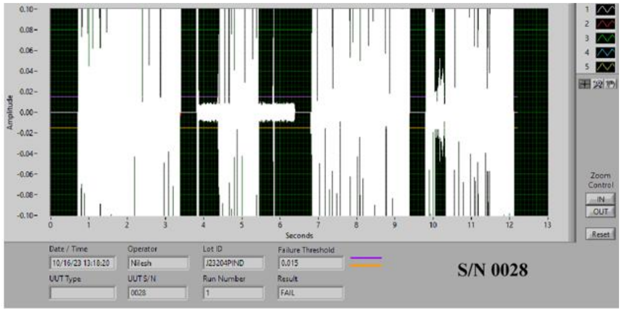
- Loose particulate within the cavity is often caused by fibers, solder residues and other erroneous elements trapped inside the cavity during the manufacturing process. Loose particles can affect the device reliability and increases the risk of latent failure.

This testing is performed on hermetic devices NOT on PEMs.

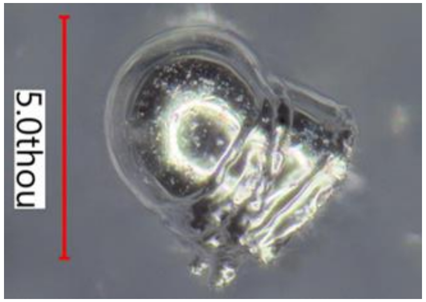
PIND failure is sometimes followed by particle capture, where a small hole is carefully drilled through the body of the part and covered by tape, then the part is shaken to allow particle to bounce around and be caught on the tape



PIND Fail



Examples of PIND Pass and Fail Results
Image Source: NASA GSFC



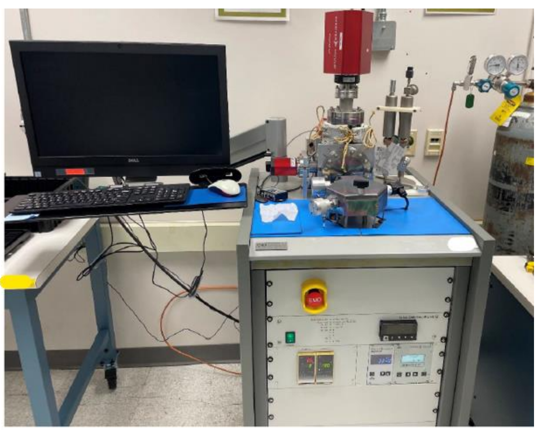
Examples of particle captured after PIND failure
Image Source: NASA GSFC

Hermetic Seal Testing
(Also known as Fine and Gross Leak Testing)

Common Test Methods:
- MIL-STD-750 TM 1071
- MIL-STD-883 TM 1014
- MIL-STD-202 TM 112

Fine and gross leak testing is used to determine the effectiveness of package seals in hermetic packages. Damaged or defective seals and feedthroughs allow ambient air/water vapor to enter the internal cavity of the device which can result in internal corrosion leading to device failures.

- Helium Hermeticity Testing
- Perfluorocarbon Gross Leak
- Radioisotope (Kr85) Dry and Wet Gross Leak
- Optical Leak Testing



Combined oxygen/helium leak tester
Image Source: NASA GSFC

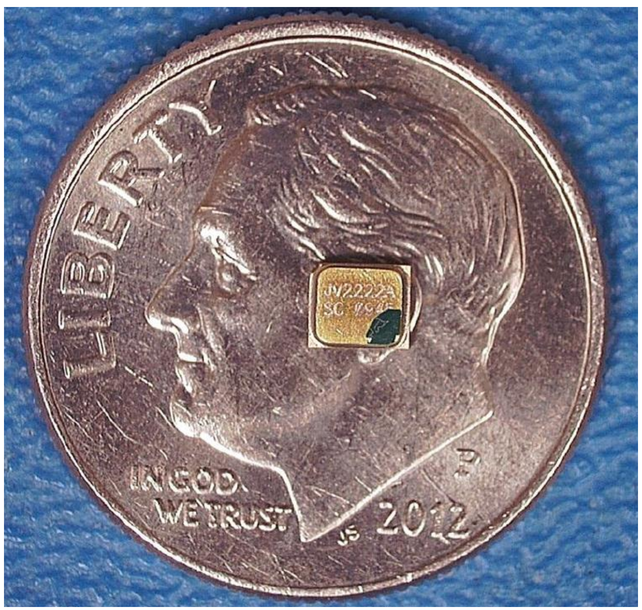
Kr85 leak tester
Image Source: Integra Tech

Example of part failing gross leak test
Image Source: Integra Tech

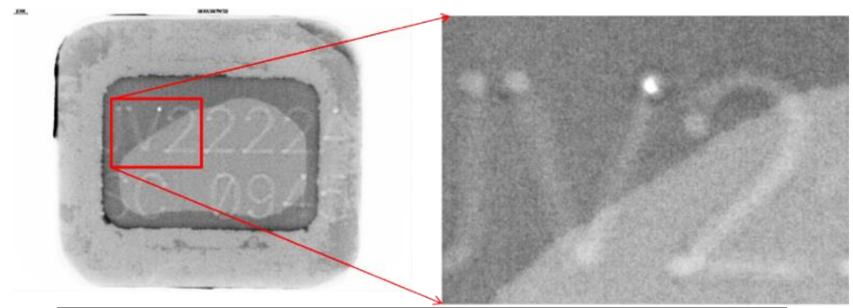
Hermetic Seal Testing
(Also known as Fine and Gross Leak Testing)

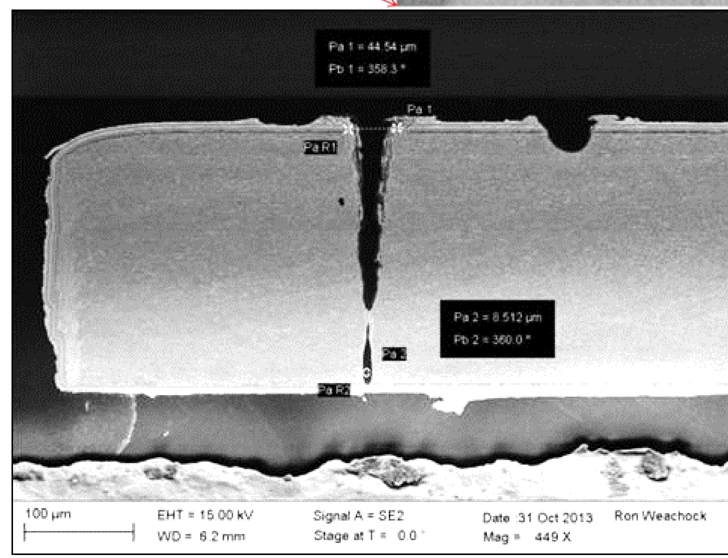
Common Test Methods:
- MIL-STD-750 TM 1071
- MIL-STD-883 TM 1014
- MIL-STD-202 TM 112

Wet gross leak test can result in false negatives.
Example:
- UB package with laser marking penetrating the lid that passed wet leak test and went on to fail in application.
- Gross leak fluid was found inside the device.
- Failure mechanism was corrosion of wirebonds in liquids that entered into the cavity



Transistor UB package failed due to moisture and corrosive material ingress through a hole in the lid
Image Source: NASA GSFC





Example of transistor package with hole in lid created by laser marking system.
X-ray image and cross-section of the lid show the hole
Device escaped hermeticity testing and failed in use due to internal corrosion
Image Source: NASA GSFC

Internal Gas Analysis (IGA)

Common Test Methods:
- MIL-STD-750 TM 1018
- MIL-STD-883 TM 1018

- Internal Gas Analysis (IGA) is performed only on cavity devices
- Performed by puncturing the device, collecting internal gas, and analyzing on a mass spectrometer, binning volatile species by their molecular weight
- Lab performing the testing will provide results in %v, where only gases being examined for will be accounted for up to 100%v
  - Some molecular weights are lumped together to report a generic category, such as fluorocarbons (FC)
  - The analysis is comprehensive for most packages, but can be confusing if some species of importance are not reported in a standard report
- Where gases come from:
  - Seal gases: ~100%v N2, 90%v/10%v N2/He, dry air (80%v N2, 19%v O2, 1%v Ar, 5ppm He)
  - Gases that evolve from internal materials: ammonia (NH3), carbon dioxide (CO2), carbon monoxide (CO) are not uncommon by-products of internal curing of epoxies and adhesives
  - Gases that ingress through non-hermetic package: water, oxygen/argon from air, fluorocarbon from gross leak testing, helium from fine leak testing. Will not see Kr85 because leftover from hermeticity testing is too small amount
- Failure Criteria:
  - Water vapor > 5,000 ppmv
  - Oxygen > 10,000 ppmv
  - Fluorocarbon > 50 ppmv
  - Other gas contents may be specified

SAMPLE ID	1	2	3
Pass/Fail	FAIL	PASS	PASS
Inlet Pressure torr	48.3	42.5	41.4
Sys. Pressure torr	1.30E-05	1.20E-05	1.20E-05
Volume cc·atm	0.231	0.201	0.196
Nitrogen ppmv	785,813	996,301	997,499
Oxygen ppmv	187,669		
Argon ppmv	8,666	179	212
Carbon Dioxide ppmv	1,879	788	840
Moisture ppmv	15,758	763	767
Hydrogen ppmv	117	1,968	683
Methane ppmv			
Ammonia ppmv			
Helium ppmv			
Fluorocarbon ppmv	97		

Example of IGA results on three samples from the same lot.
Sample 1 shows signs of atmospheric and fluorocarbon ingress
Image Source: NASA GSFC

Scanning Acoustic Microscopy (SAM)

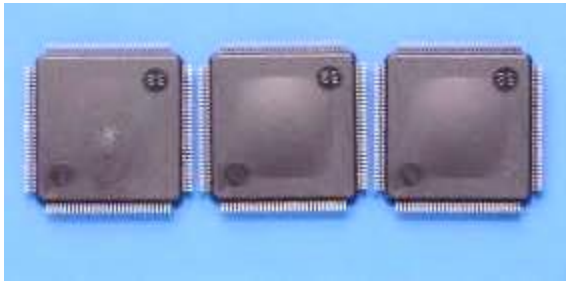
Common Test Methods:

- MIL-STD-1580 Req 16.5
- JEDEC J-STD 020
- MIL-STD-883 TM 2030

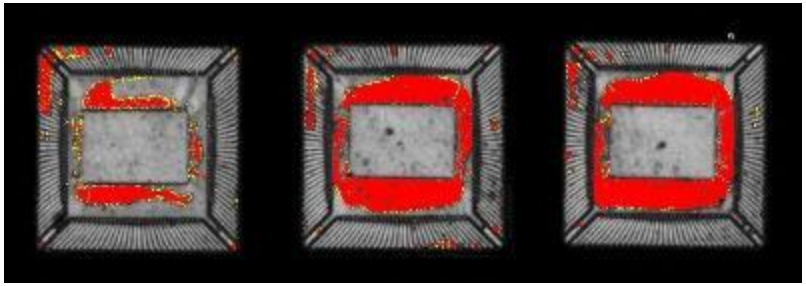
Scanning Acoustic Microscopy (or Acoustic Microscopy, or Ultrasonic Inspection) is a non-destructive method used to find defects such as delamination, voids and cracks that can occur in plastic packages.

This type of microscopy uses sound energy to image a device through the use of transducers. The devices are submerged in a liquid medium to ensure the ultrasound waves propagate to and through the devices.

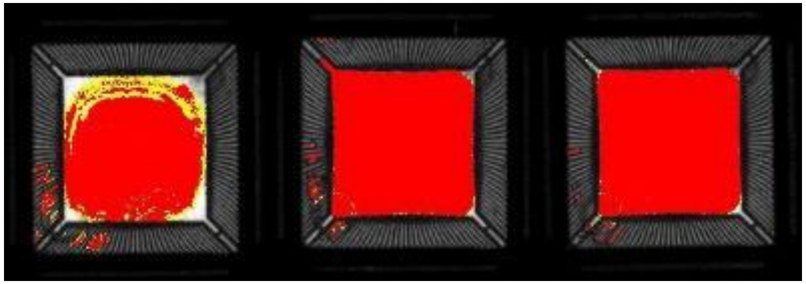
The sound waves interact with the sample in various ways: they can be reflected, transmitted, or scattered depending on the material properties and the presence of defects such as voids and delaminations.



Optical overview of the parts
Image Source: Integra Tech



Acoustic Microscopy at top of leadframe
Image Source: Integra Tech

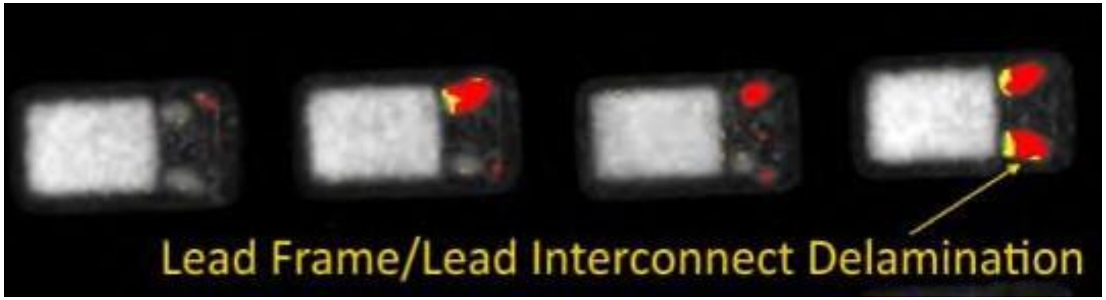


Acoustic Microscopy above the die
Image Source: Integra Tech

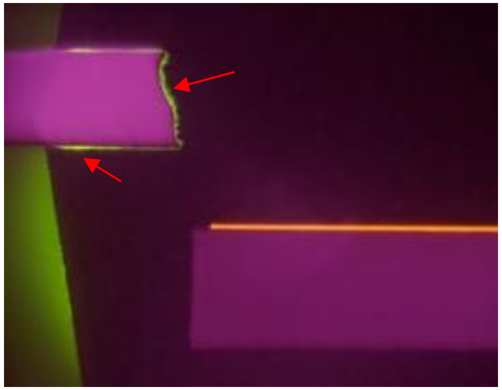
Dye Penetrant Test for PEMs

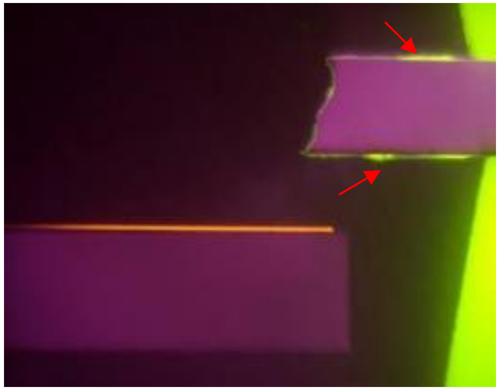
Common Test Method:
- MIL-STD-883 TM 1034

This technique is used to verify suspect delamination typically seen during Acoustic Microscopy. This technique utilizes a low viscosity liquid penetrant which is mixed with a fluorescent powder and an accelerator. After the device is subjected to dye penetrant it is potted and cross sectioned for inspection under Ultraviolet(UV) illumination.



Acoustic Microscopy image of a device
Image Source: Integra Tech





Optical images of cross-sectioned device under UV light showing ingress of UV fluorescent dye around the lead frames
Image Source: Integra Tech

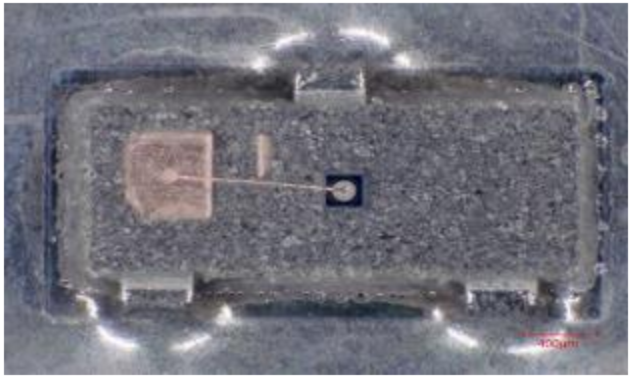
Chemical Decapsulation

Common Test Method:
- MIL-STD-1580 Req 16.5.1.6

Chemical de-encapsulation is performed by using acids, typically Nitric and Sulfuric or a mixture of both are used to remove the plastic resin packaging of a device.

The acid is applied in a specified area to fully expose internal components, such as the bond wires and the die of a device for inspections.

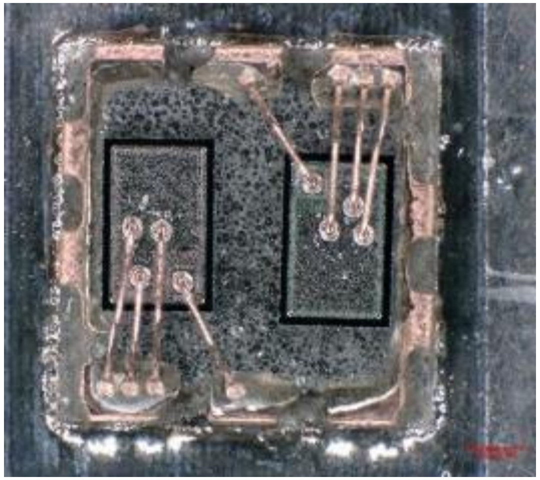
Attention should be paid to wire materials: copper (Cu) wire is more susceptible to chemical attach than aluminum (Al) or gold (Au)



Decapsulated plastic encapsulated device with copper (Cu) wirebond
Image Source: Integra Tech

Decapsulated plastic encapsulated device with gold (Au) wirebonds
Image Source: Integra Tech

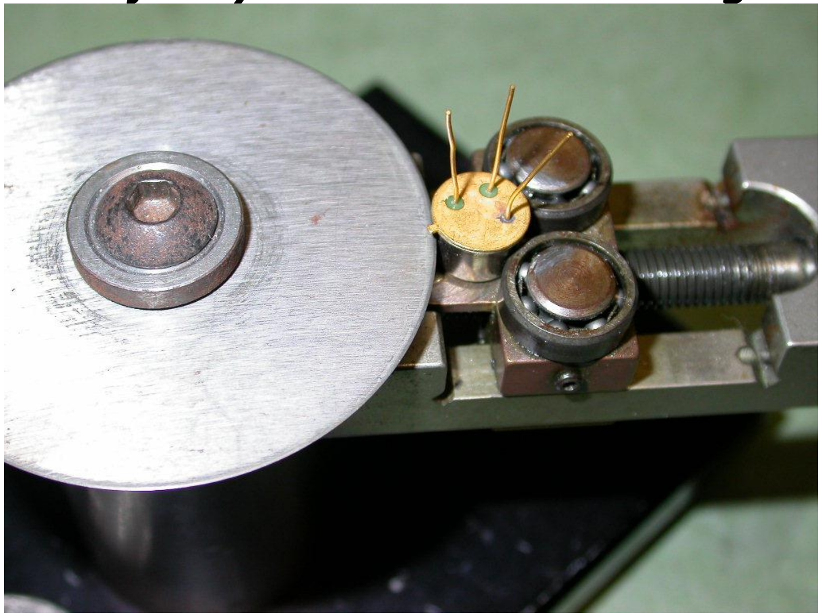
Decapsulated plastic encapsulated device with aluminum (Al) wirebonds
Image Source: Integra Tech



Decapsulated plastic encapsulated device with copper (Cu) wirebonds
Image Source: Integra Tech

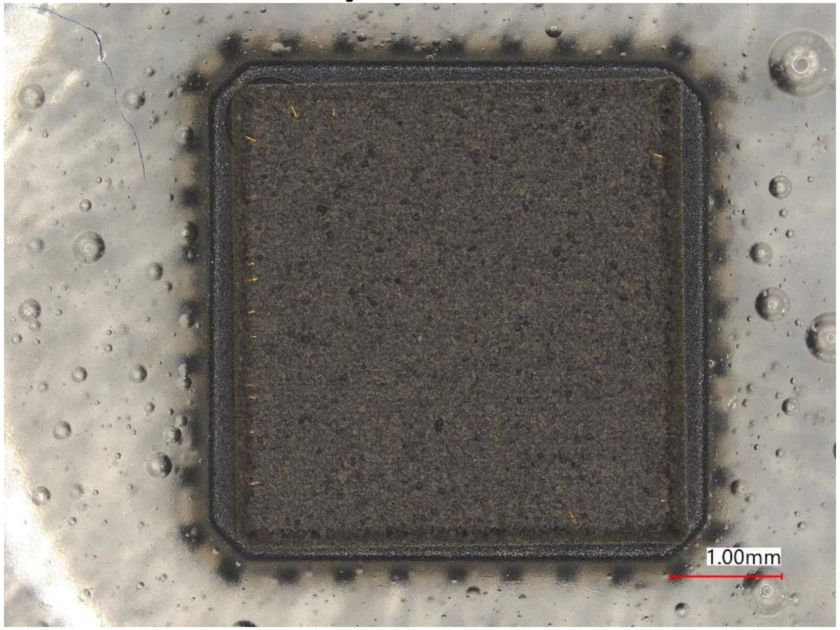
Mechanical & Laser Decapsulation Tools

Can Opener for Cylindrical Metal Packages



Mechanical decapsulation of a transistor can package
Image Source: NASA GSFC

Laser Decapsulation For Plastic Encapsulated Microcircuits



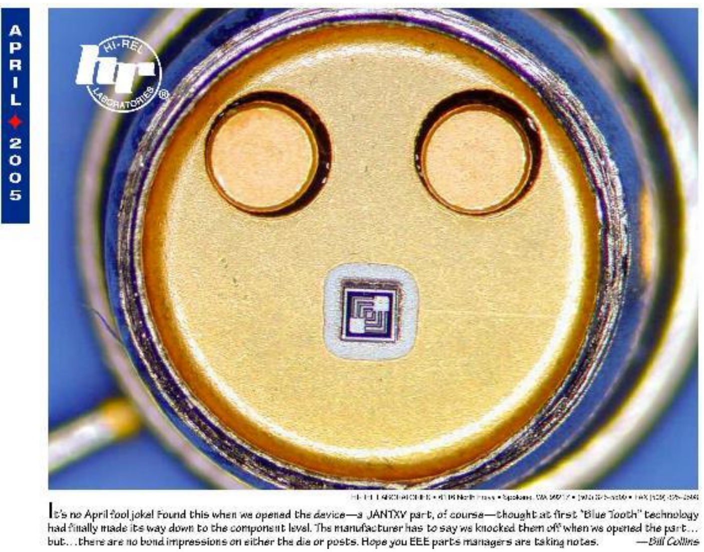
Laser decapsulation of plastic encapsulated device in progress – showing tops of wirebonds
Image Source: NASA GSFC

Internal Visual Inspection (following decapsulation)

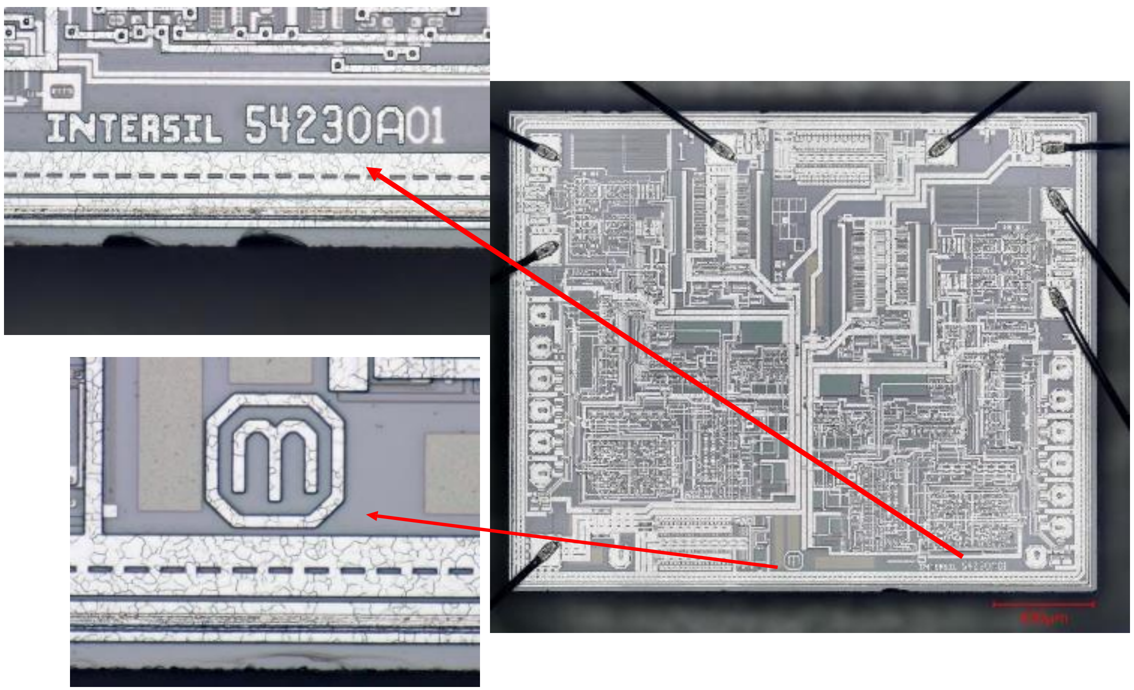
Common Test Methods:

- MIL-STD-750 TM 2069, 2070, 2072, 2073, 2074
- MIL-STD-883 TM 2010, 2017

Once the die and bond wires are exposed internal visual inspection is performed. The purpose of this examination is to verify that internal materials, design and construction are and that the sample set is homogeneous. At this point, the die and all markings are optically documented.



Internal optical examination of a transistor showing no wirebonds
Image Source: HiRel Labs

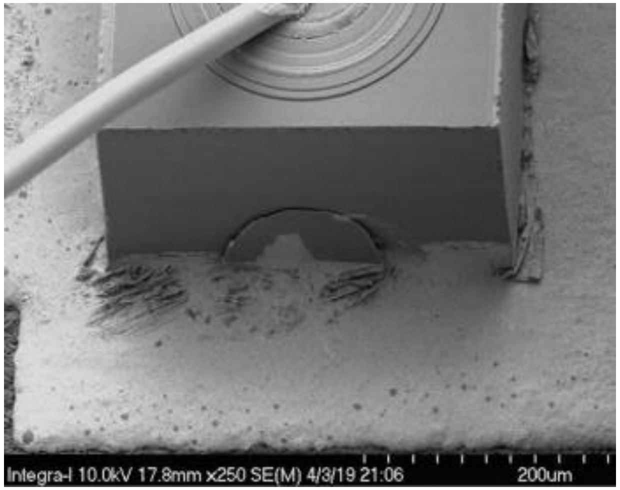


Internal optical examination of a die showing die markings
Image Source: Integra Tech

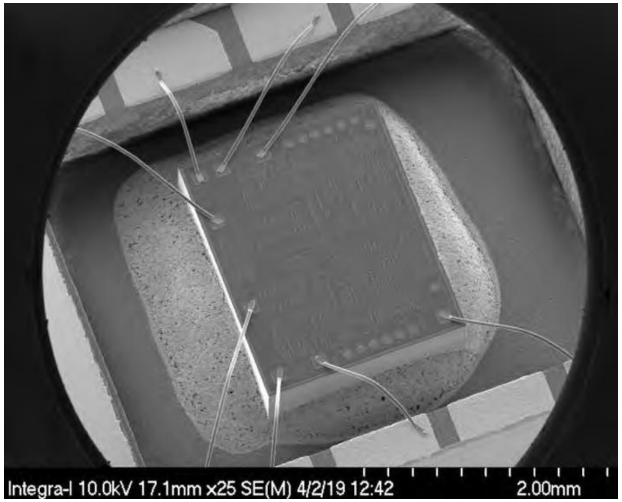
Scanning Electron Microscopy
(SEM) Inspection

SEM inspection is typically performed after internal visual inspections at up to several thousand x magnification.

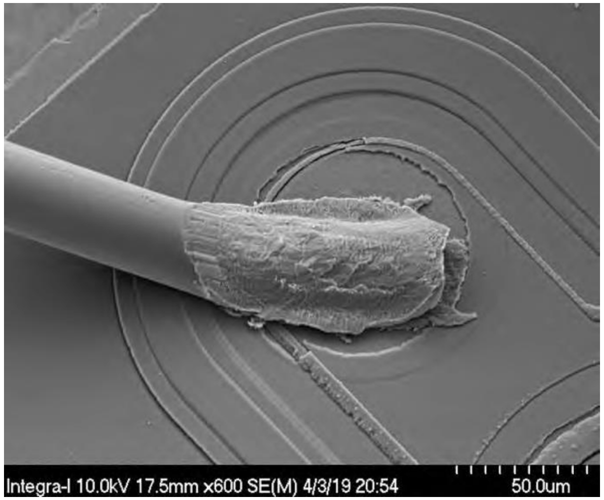
The purpose of this inspection is to further document any internal visual findings or failures. SEM documentation of the wire size is also performed to aid in wire bond pull activities.



Crack in die
Image Source: Integra Tech



Overview of a die in SEM
Image Source: Integra Tech



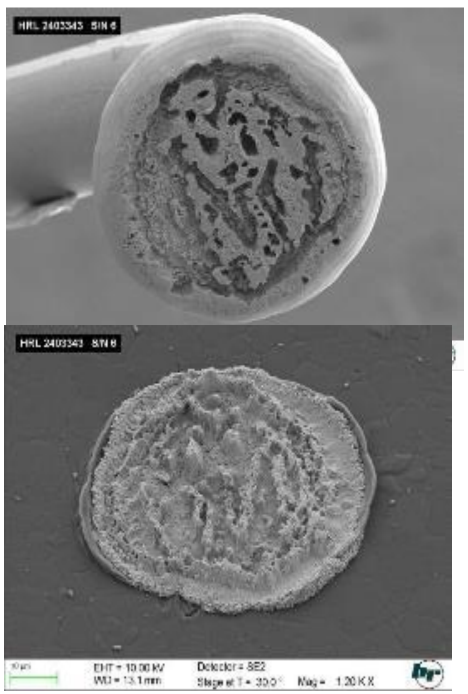
Displaced bond over adjacent metal
Image Source: Integra Tech

Wire Bond Pull and Wire Bond Shear

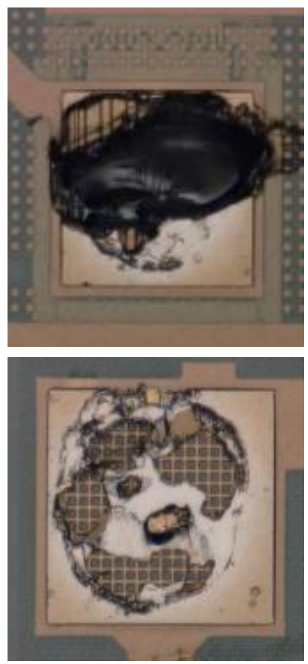
Common Test Methods:
- MIL-STD-750 TM 2037
- MIL-STD-883 TM 2011
- JESD22-B116

Wire bonds provide electrical connection between the silicon chip andthe external leads of the device. The wire is typically made of gold (Au), aluminum (Al) or copper (Cu). In some cases, silver (Ag) wire is used.

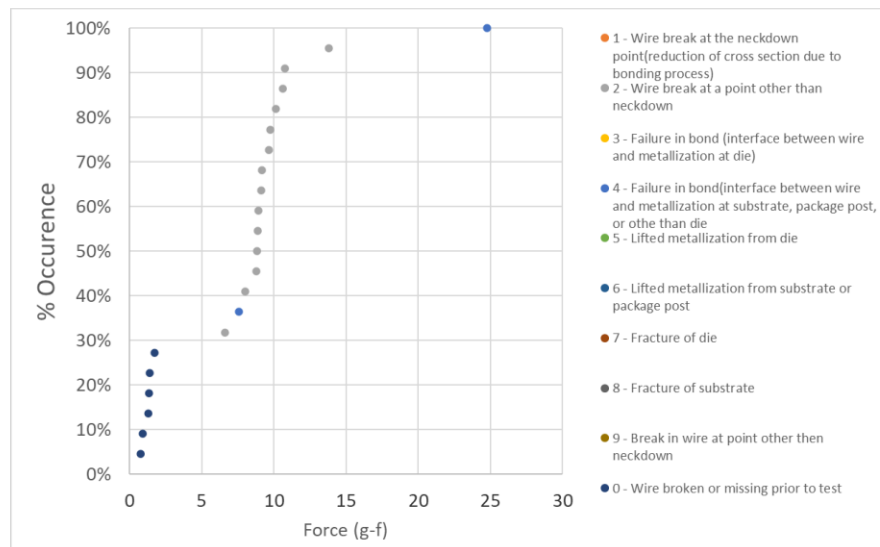
- The purpose of Wire Pull testing is to measure wirebond strengths, evaluate bond strength distributions, and to determine compliance with specified bond strength requirements.
- Wire Bond Shear testing provides a means for determining the strength and integrity of the metallurgical bond of a ball bond to a die or package bonding surface.



SEM image of low bond pull wire lifting from die
Image Source: HiRel Labs



Optical Images of cratering under the ball bond
Image Source: Integra Tech



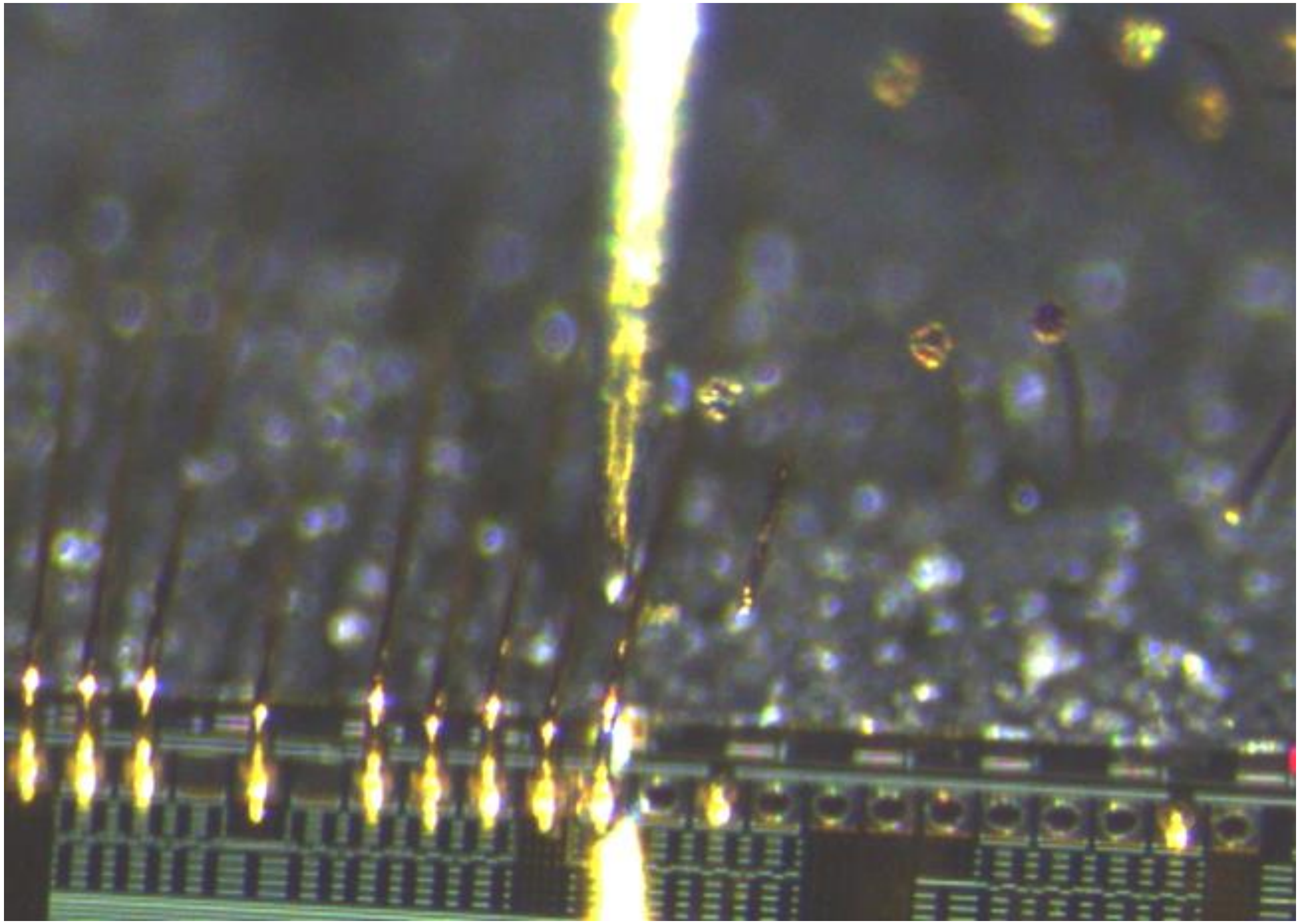
Example of cumulative distribution plot of wirebond strength showing grouping of bond strength. This grouping shows a sub-population of wires with low bond pull strength
Image Source: NASA GSFC

Wire Bond Pull and Wire Bond Shear

Common Test Methods:

- MIL-STD-750 TM 2037
- MIL-STD-883 TM 2011
- JESD22-B116

Example of wirebond pull in action



Video Source: Integra Tech

Die Shear Test

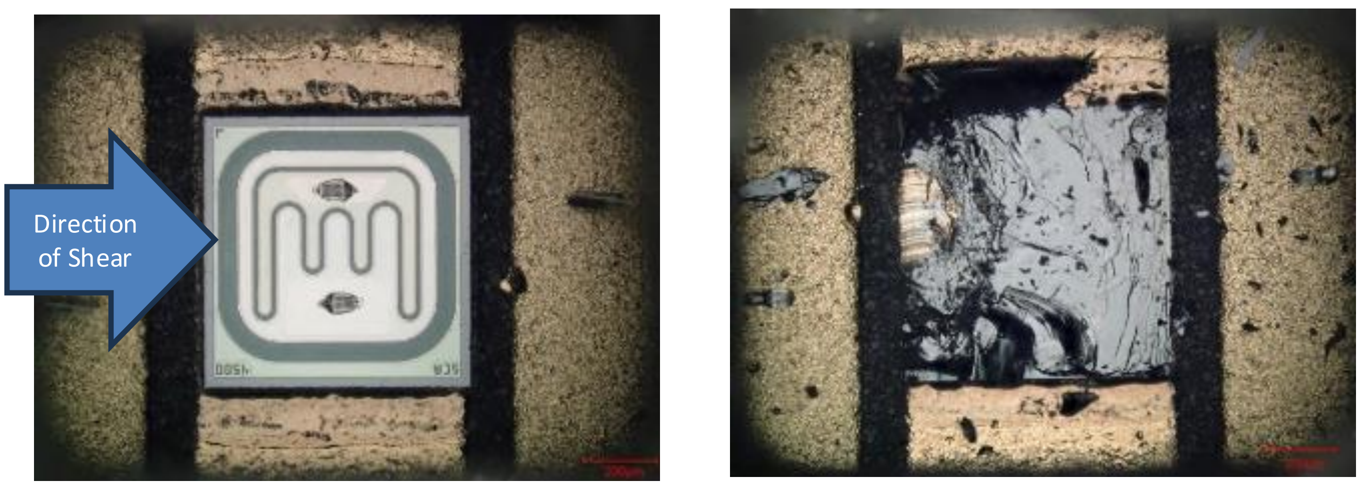
Common Test Methods:

- MIL-STD-750 TM 2017
- MIL-STD-883 TM 2019

The purpose of this test is to determine the integrity of materials and procedures used to attach the semiconductor die or surface mounted elements to the package header or substrate. This test is based on a measure of force applied to the die.

A die contact tool applies a force that is sufficient to shear the die from the substrate or header. The die strength must meet the required limit as specified in the MIL-STD.

This testing is typically only performed on hermetic devices.



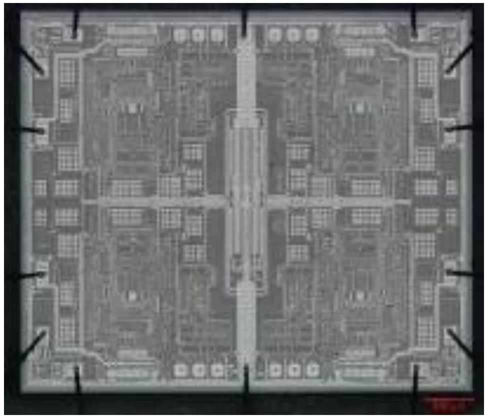
Optical Images of die before and after die shear
Image Source: Integra Tech

SEM Metallization Inspection

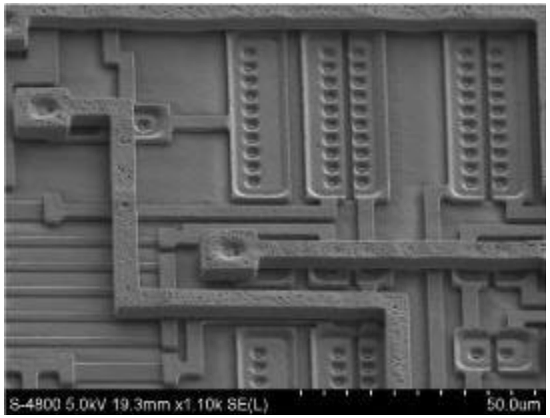
Common Test Methods:
- MIL-STD-750 TM 2077
- MIL-STD-883 TM 2018

This test method is performed to ensure quality and acceptability of device interconnect metallization on non-planar oxide dice. This inspection is not required on planar type technology.

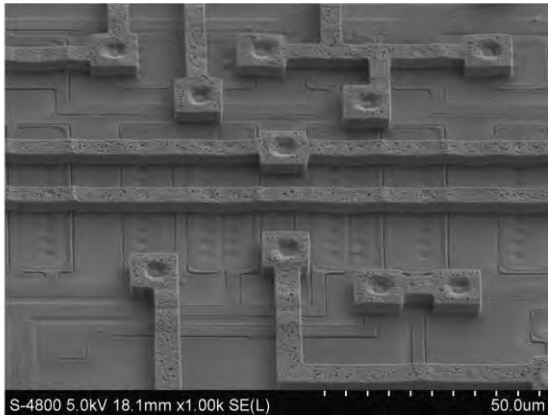
SEM Metallization inspection addresses the specific metallization defects that are batch process oriented, and which can best be identified utilizing this method.



Optical Images of die
Image Source: Integra Tech



Scanning Electronic Microscopy of die metallization
Image Source: Integra Tech

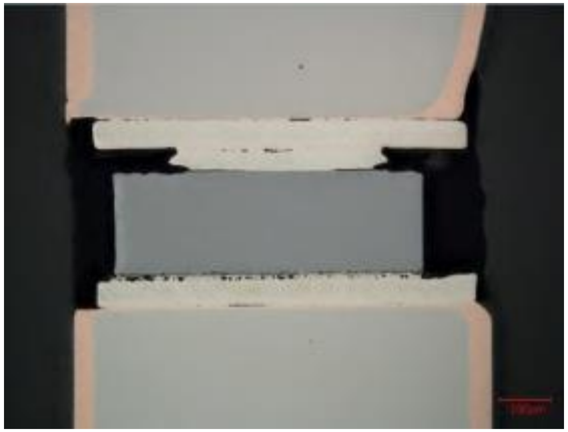


Scanning Electronic Microscopy of die metallization
Image Source: Integra Tech

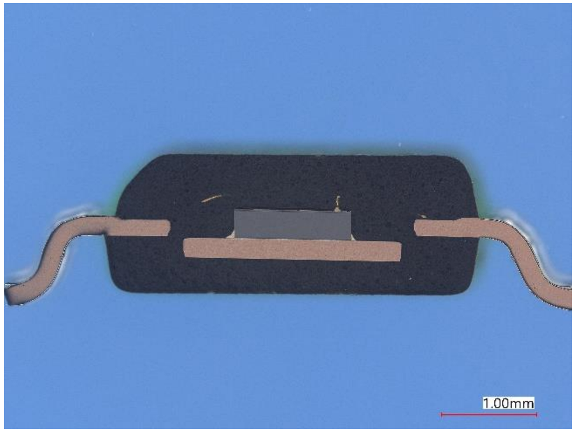
Cross Section

The cross-sectioning process provides access to the device internal structure, its materials and design. Such components as diodes and capacitors and PEMs are often subjected to cross-sectioning to detect the defects which could not be found non-destructively.

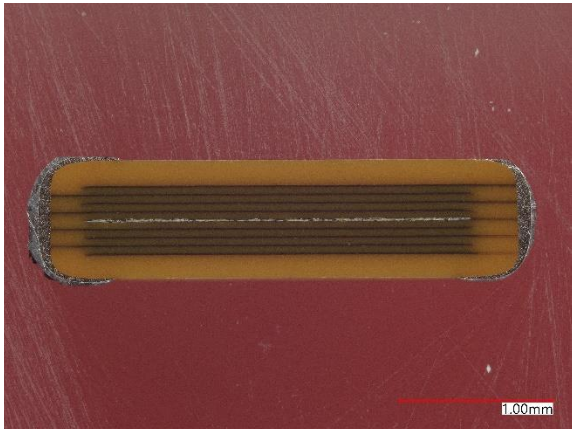
Criteria are usually written into MIL-STD-1580 requirements for each commodity.



Optical image of cross section: glass body diode
Image Source: Integra Tech

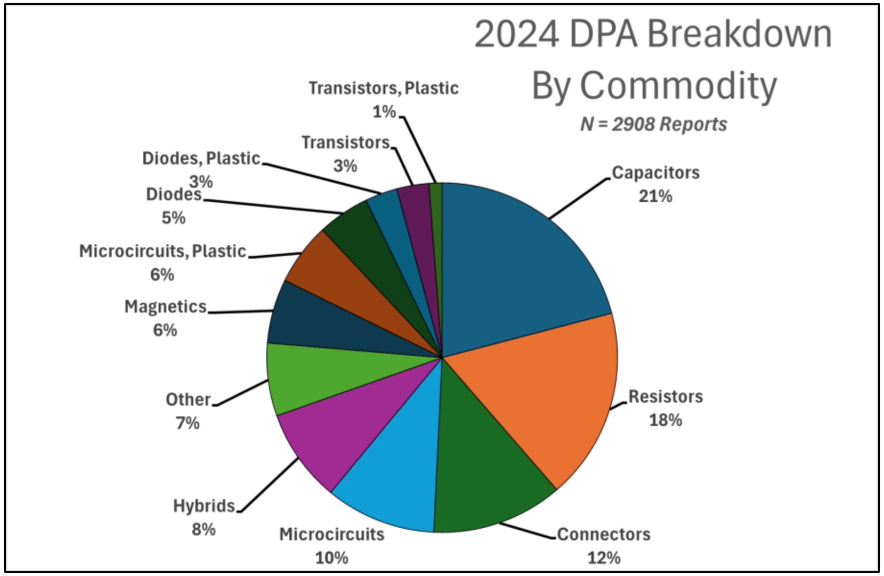


Optical image of cross section: microcircuit
Image Source: NASA GSFC

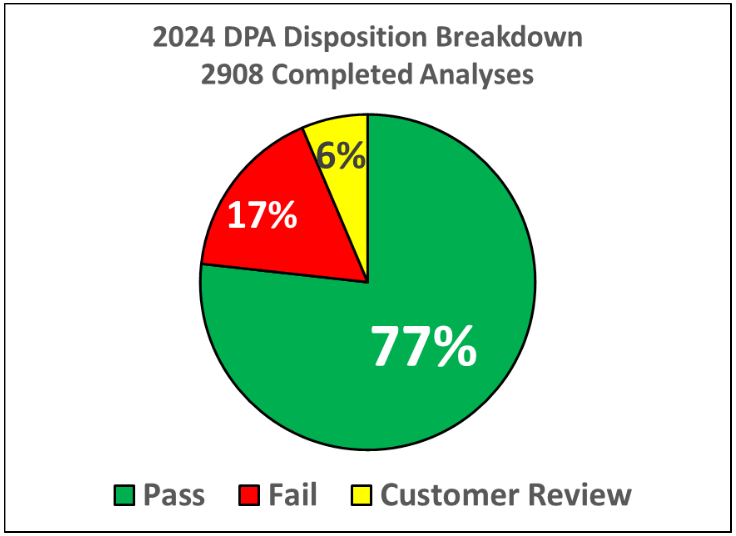


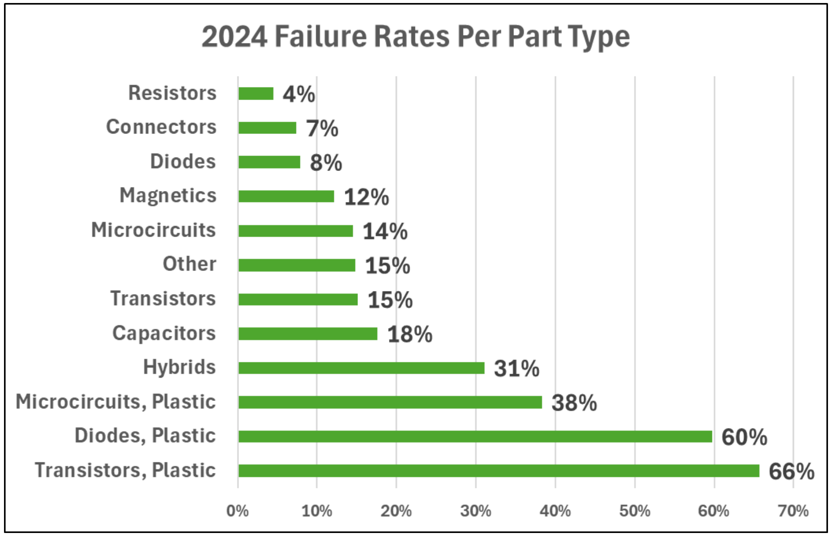
Optical image of cross section: ceramic chip capacitor with internal delamination
Image Source: NASA GSFC

Statistics of DPA 2024



Data Source: Hi-Rel Labs

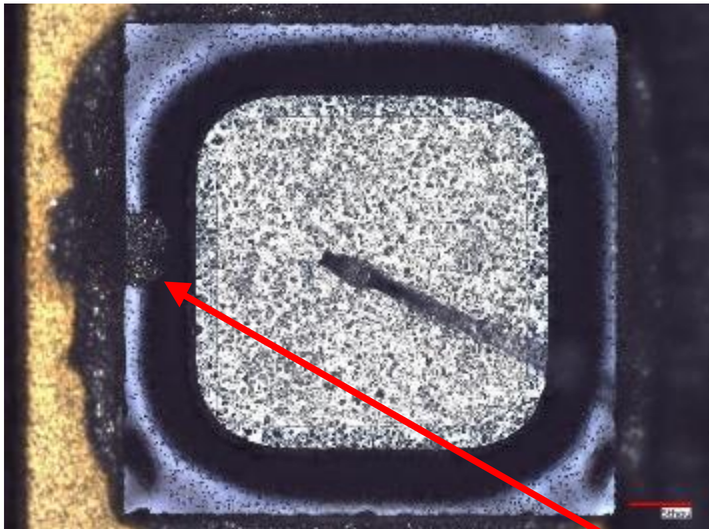




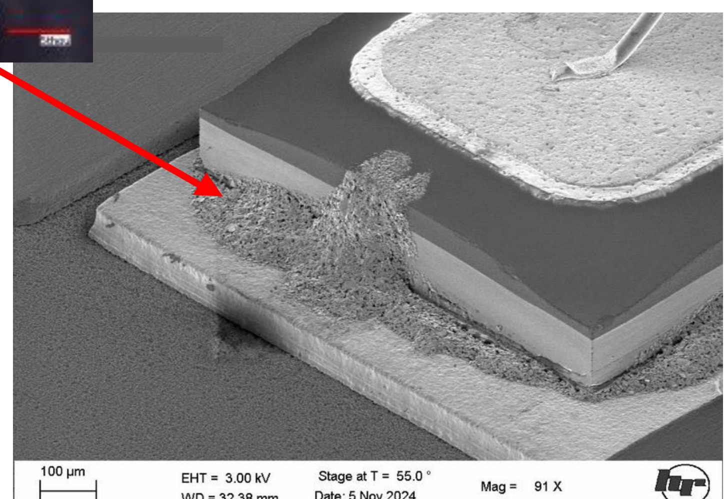
Questions?

Backup
Why Do DPA?

Visual Inspection

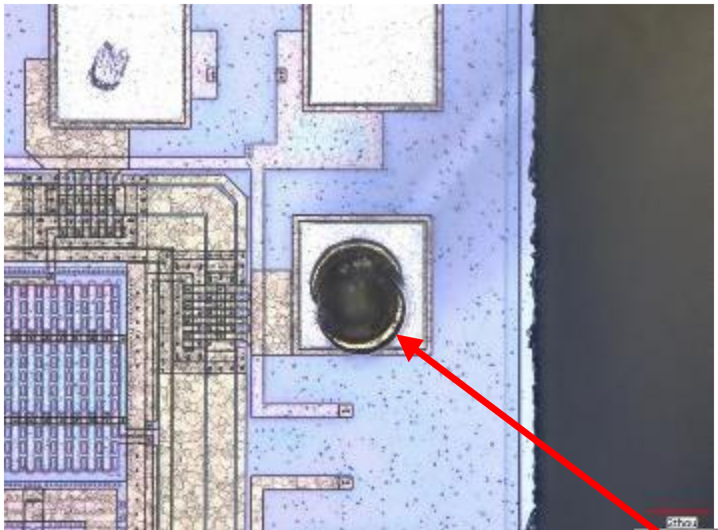


Attach Extending to the Die Surface

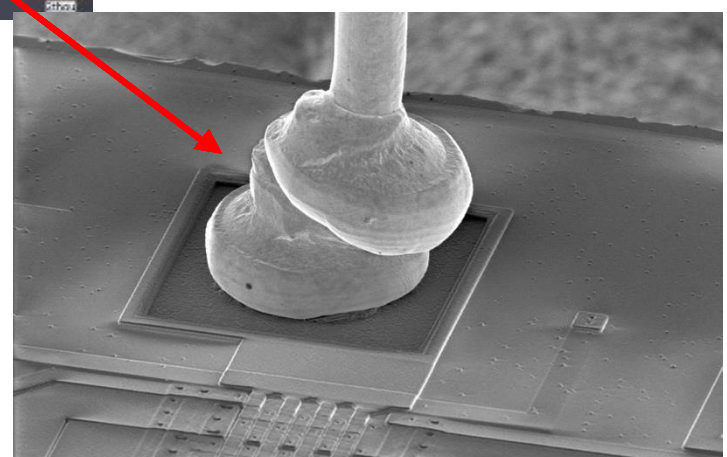


Images Source: HiRel Labs

Visual Inspection

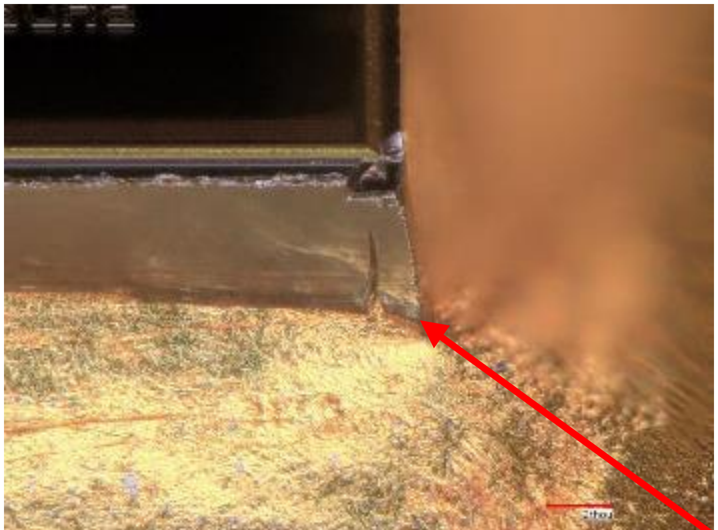


Misaligned
Compound Bond

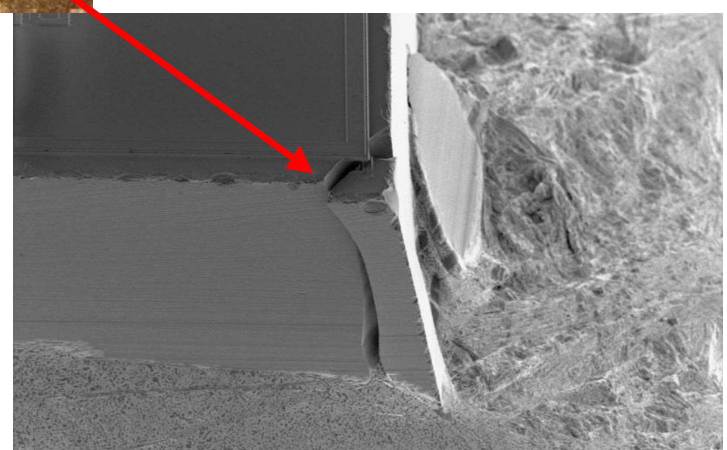


Images Source: HiRel Labs

Visual Inspection

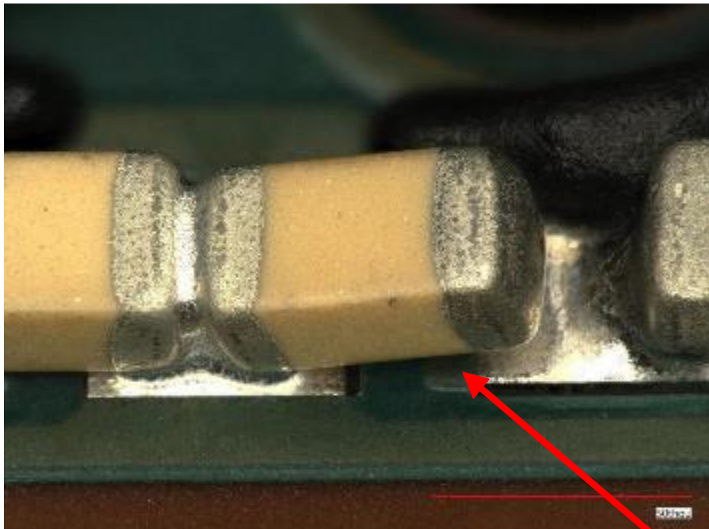


Silicon Shard

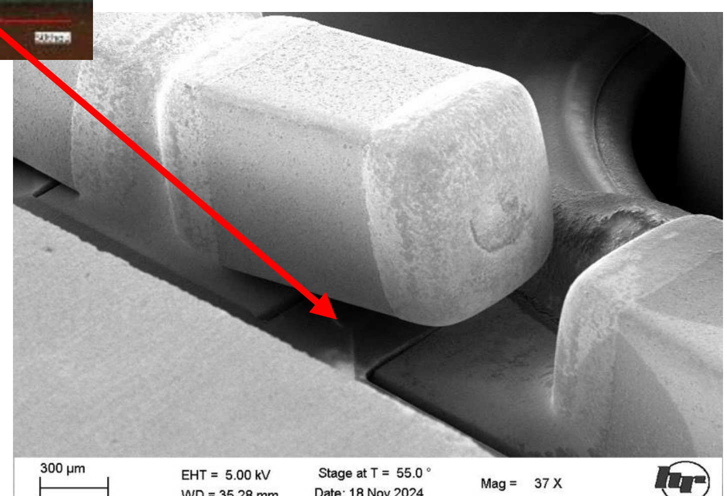


Images Source: HiRel Labs

Visual Inspection

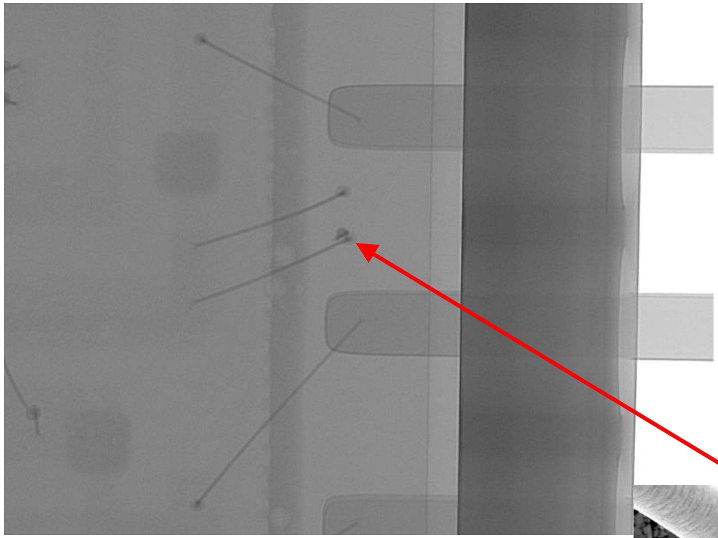


Unsoldered Component Termination



Images Source: HiRel Labs

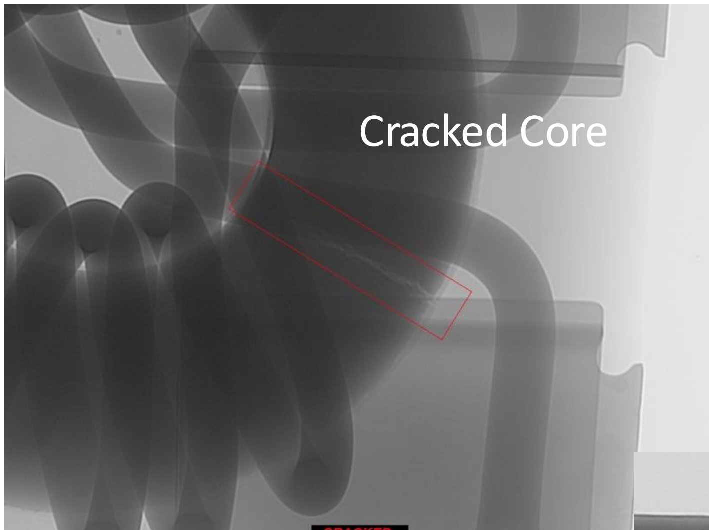
Radiography

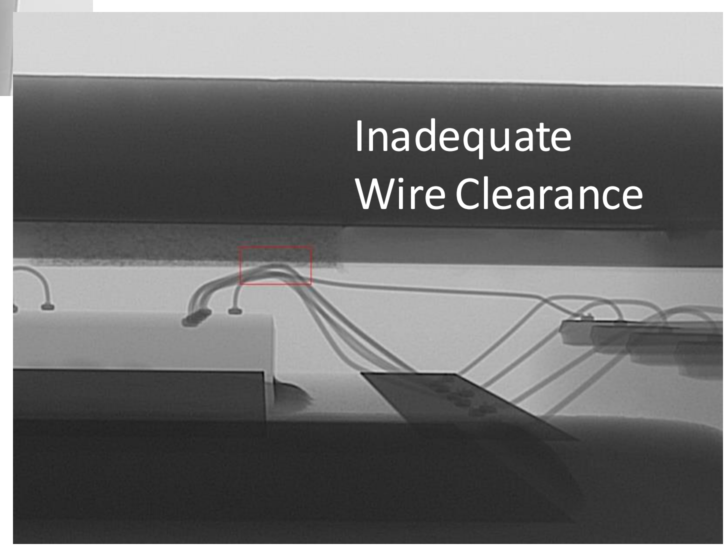


Extraneous Material

Images Source: HiRel Labs

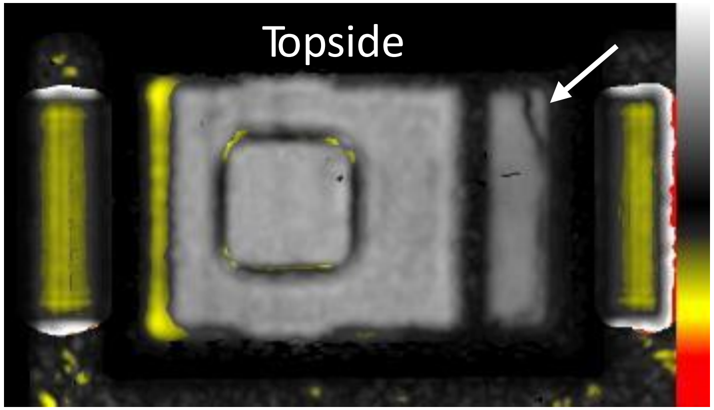
Radiography

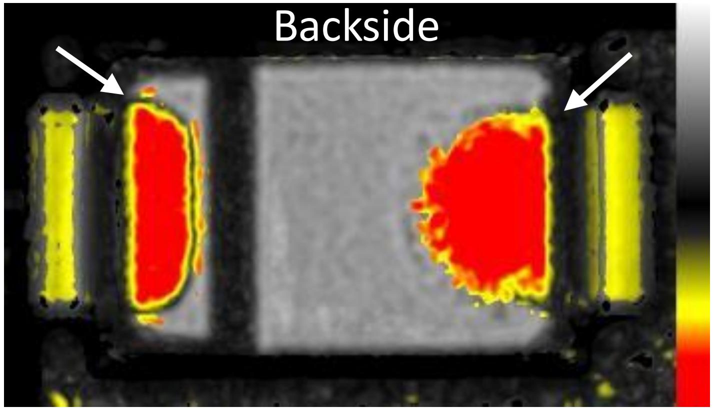




Images Source: HiRel Labs

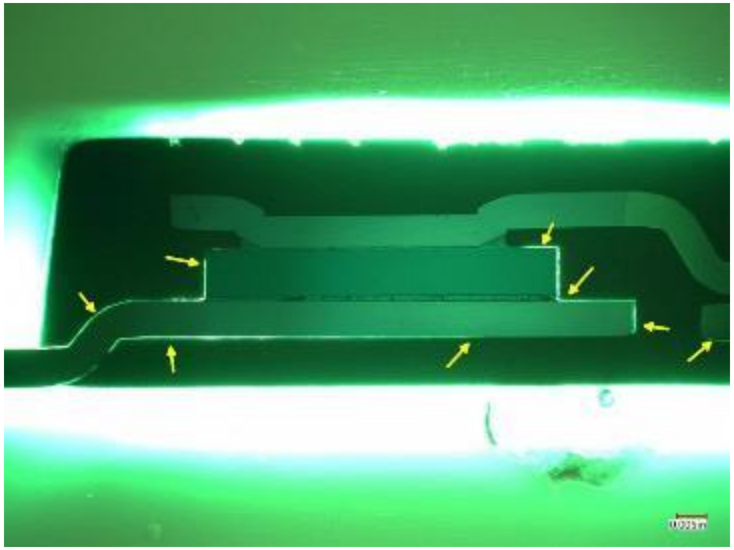
SAM and Cross-section





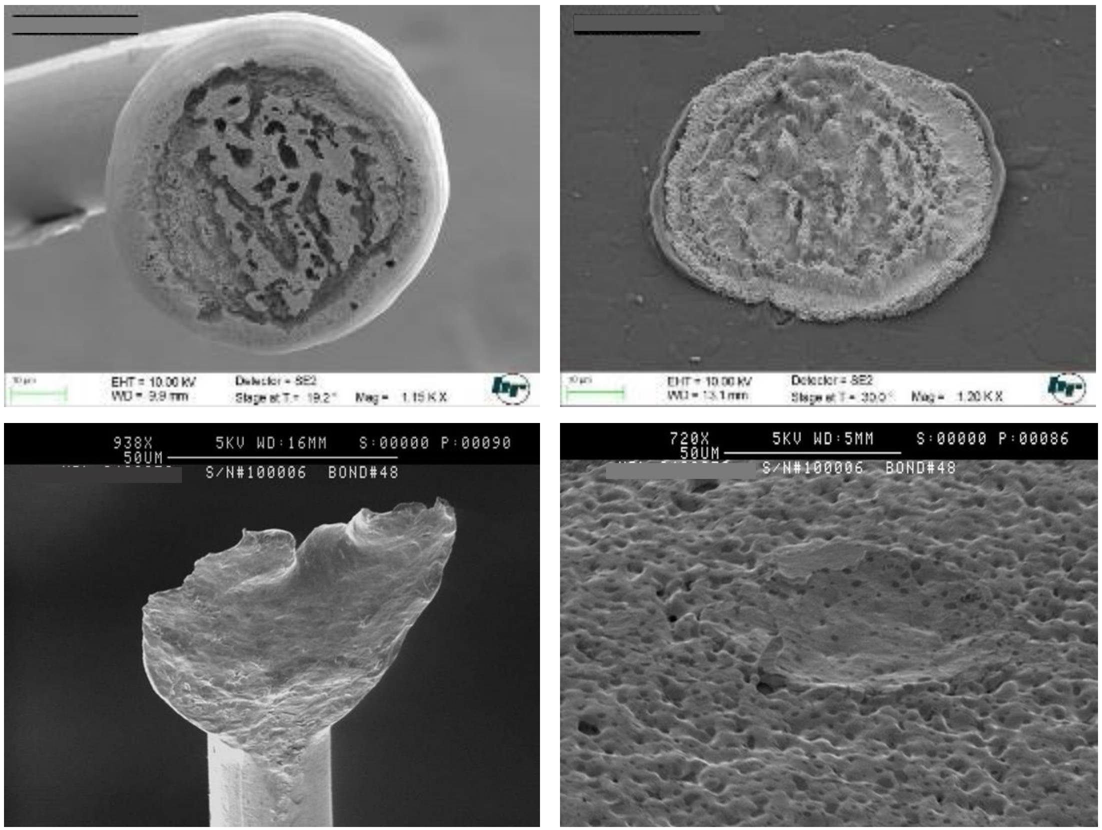
Images Source: HiRel Labs

Delaminated Package



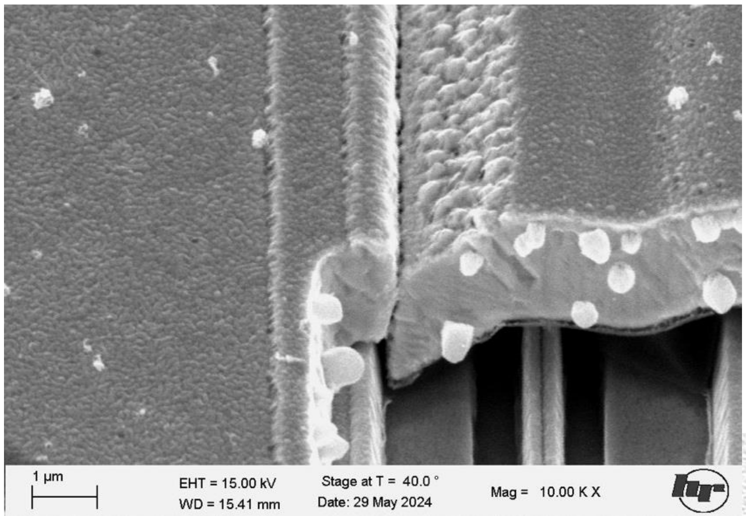
Bond Pull

Low Force Bond Lifts

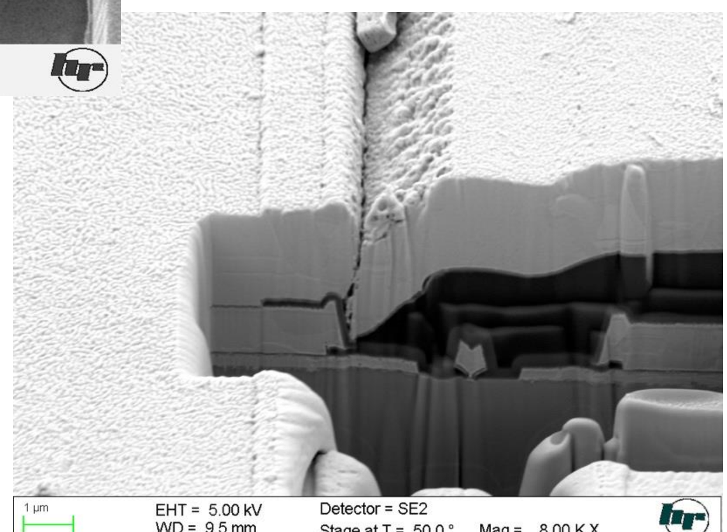


Images Source: HiRel Labs

Step Coverage

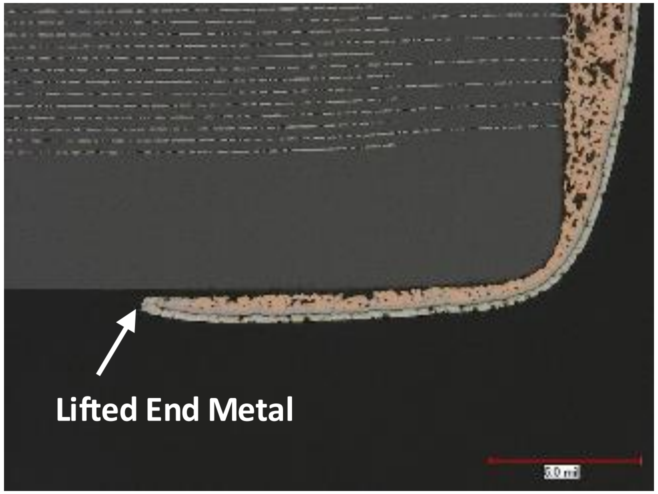


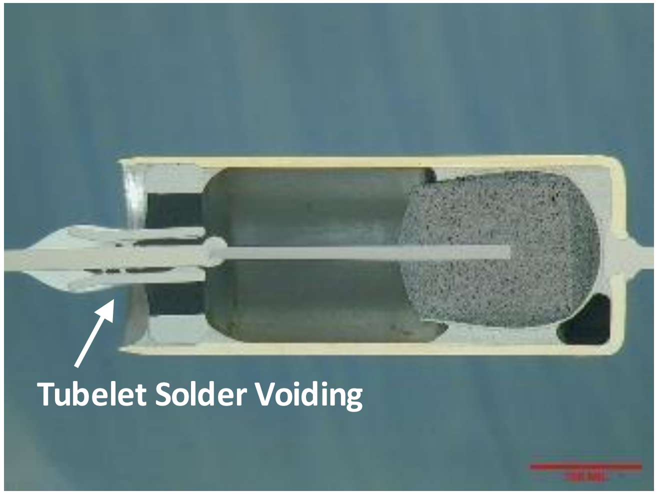
Poor Step Coverage

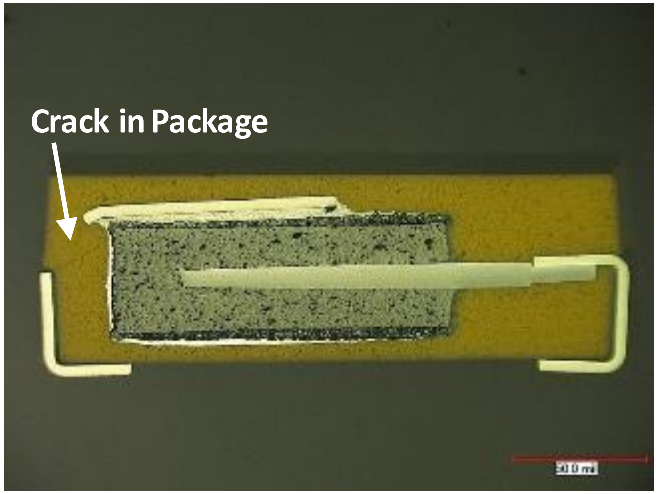


Images Source: HiRel Labs

Cross-section

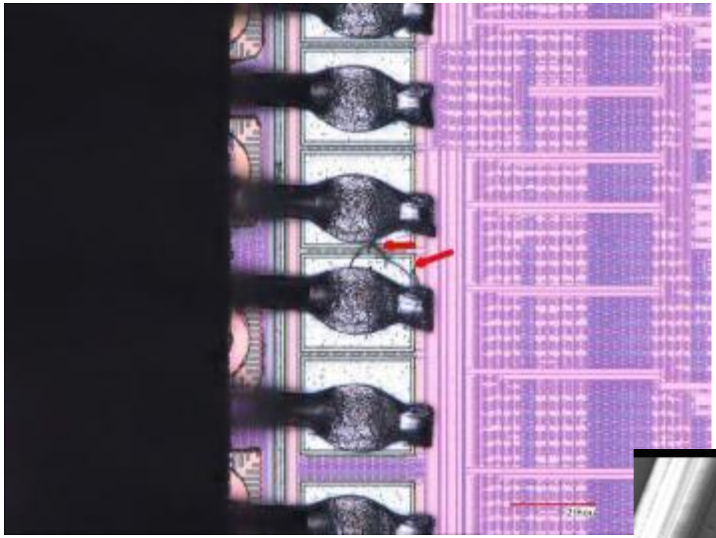


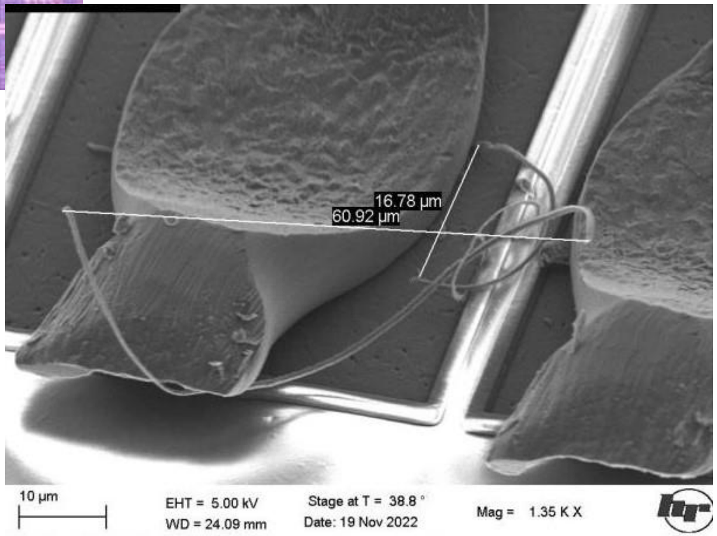




Images Source: HiRel Labs

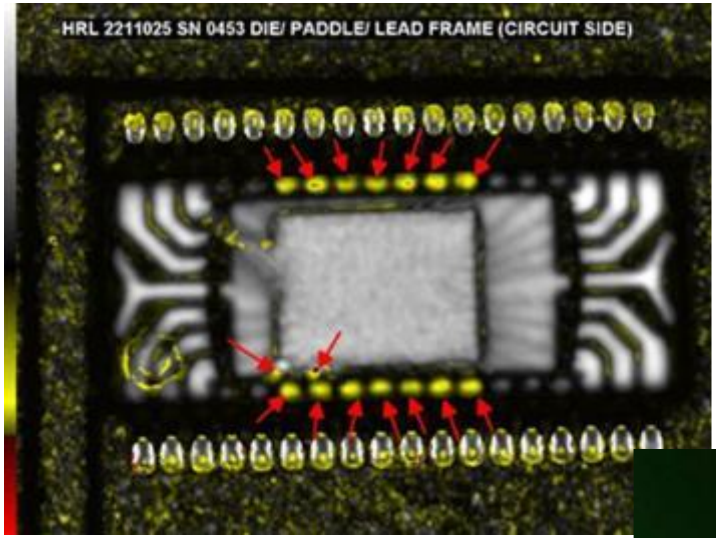
Loosely Attached Debris

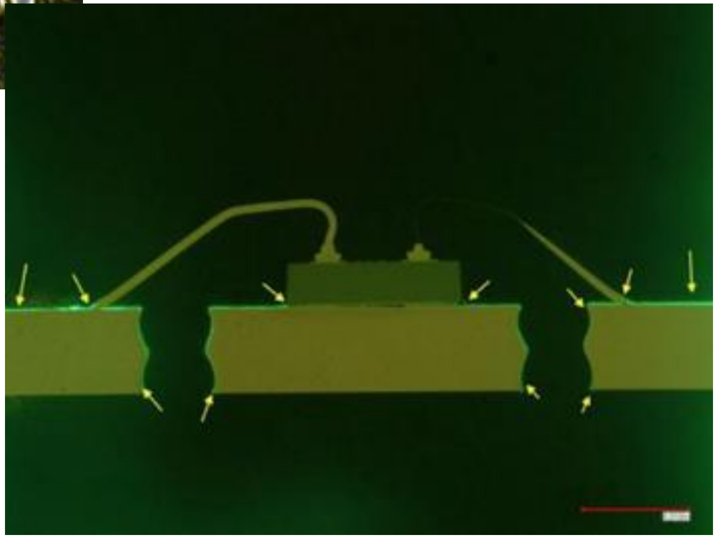




Images Source: HiRel Labs

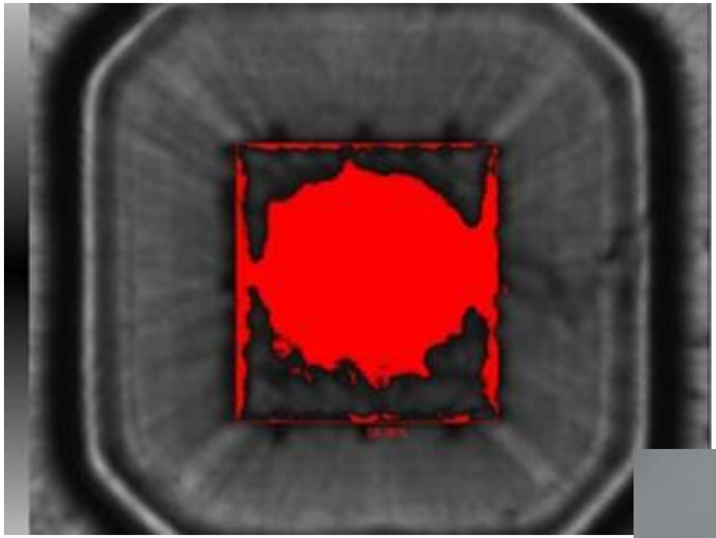
Delaminated Packages

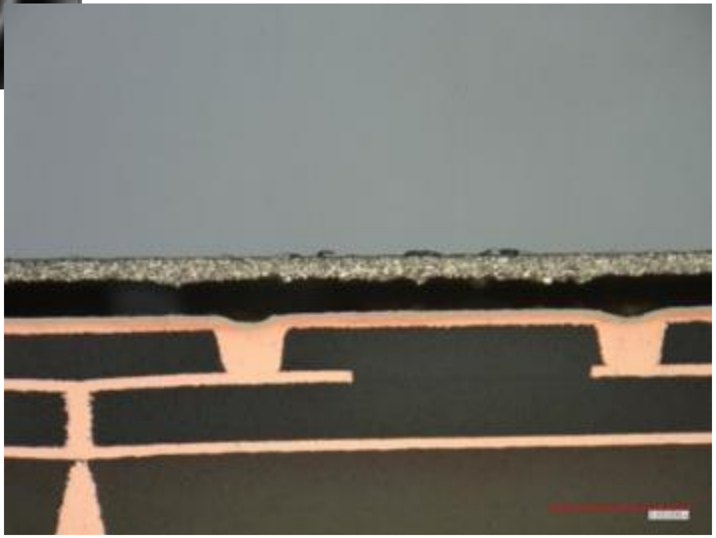




Images Source: HiRel Labs

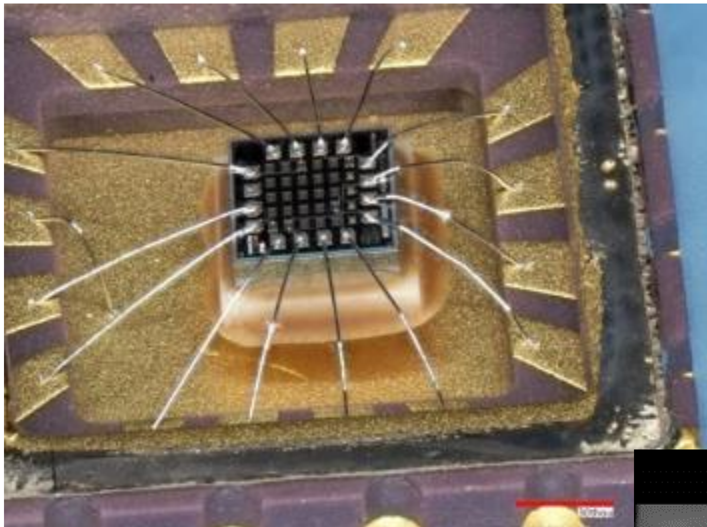
Poor Die Attach

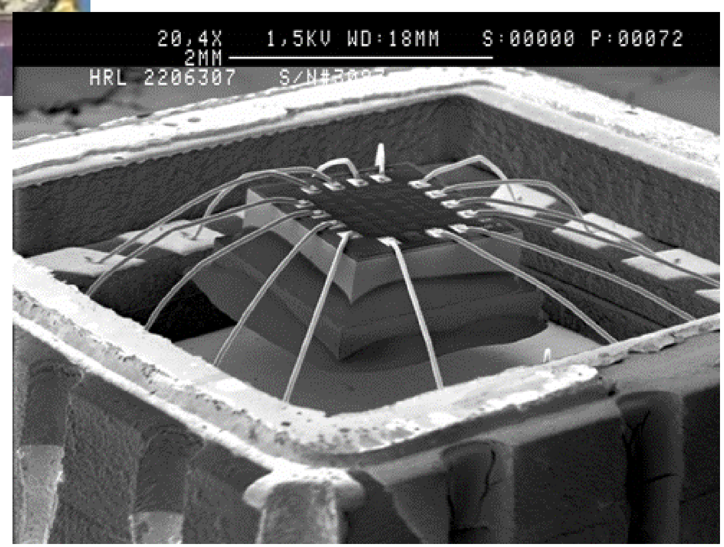




Images Source: HiRel Labs

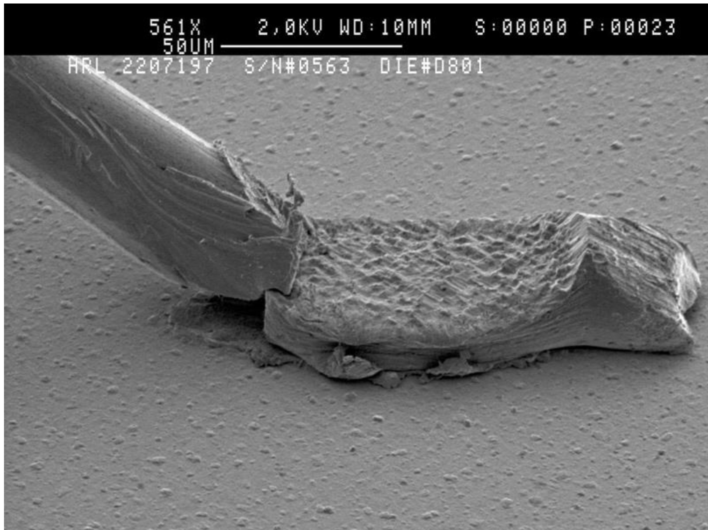
Poor Die Attach

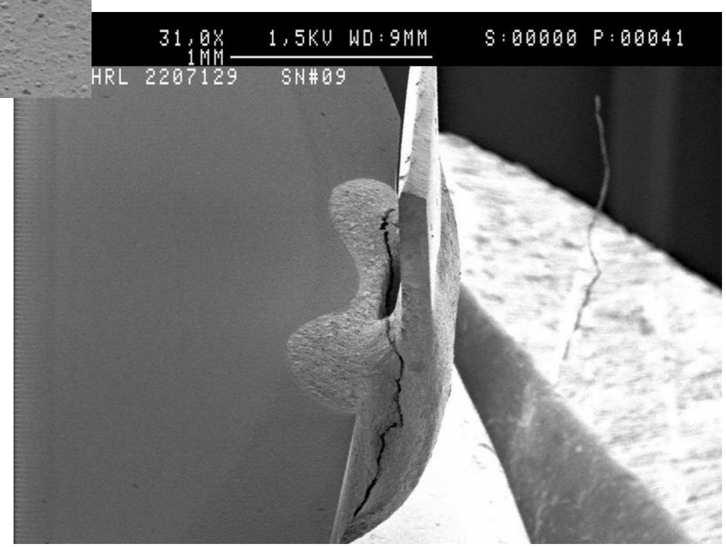




Images Source: HiRel Labs

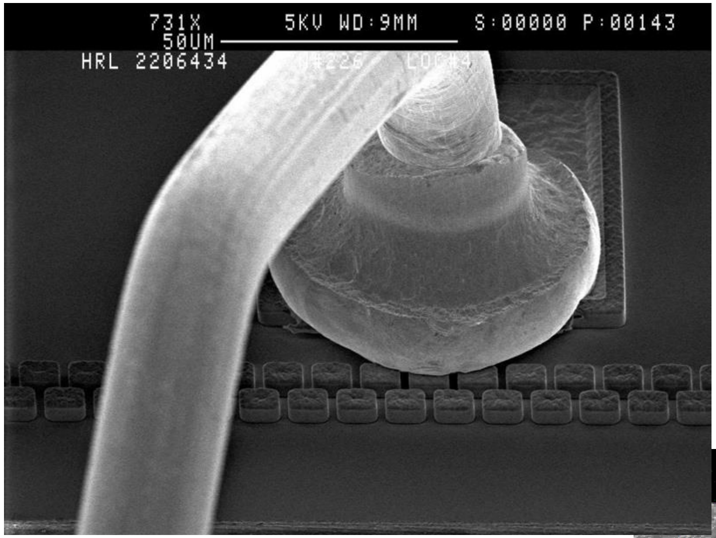
Fractured Connections

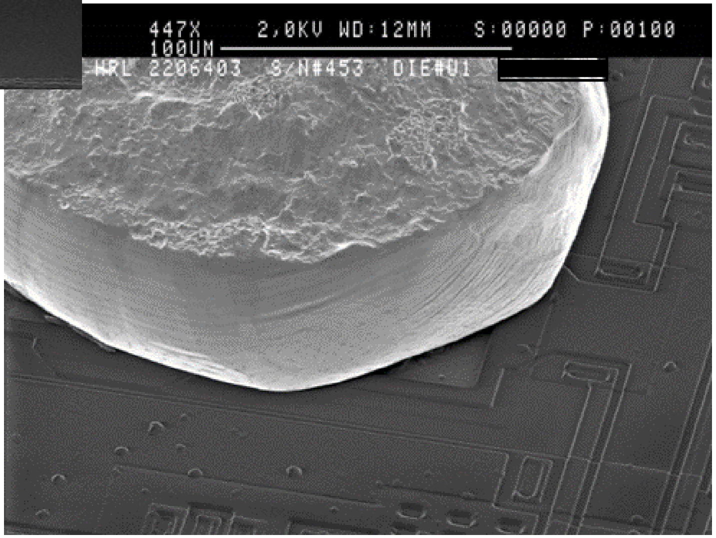




Images Source: HiRel Labs

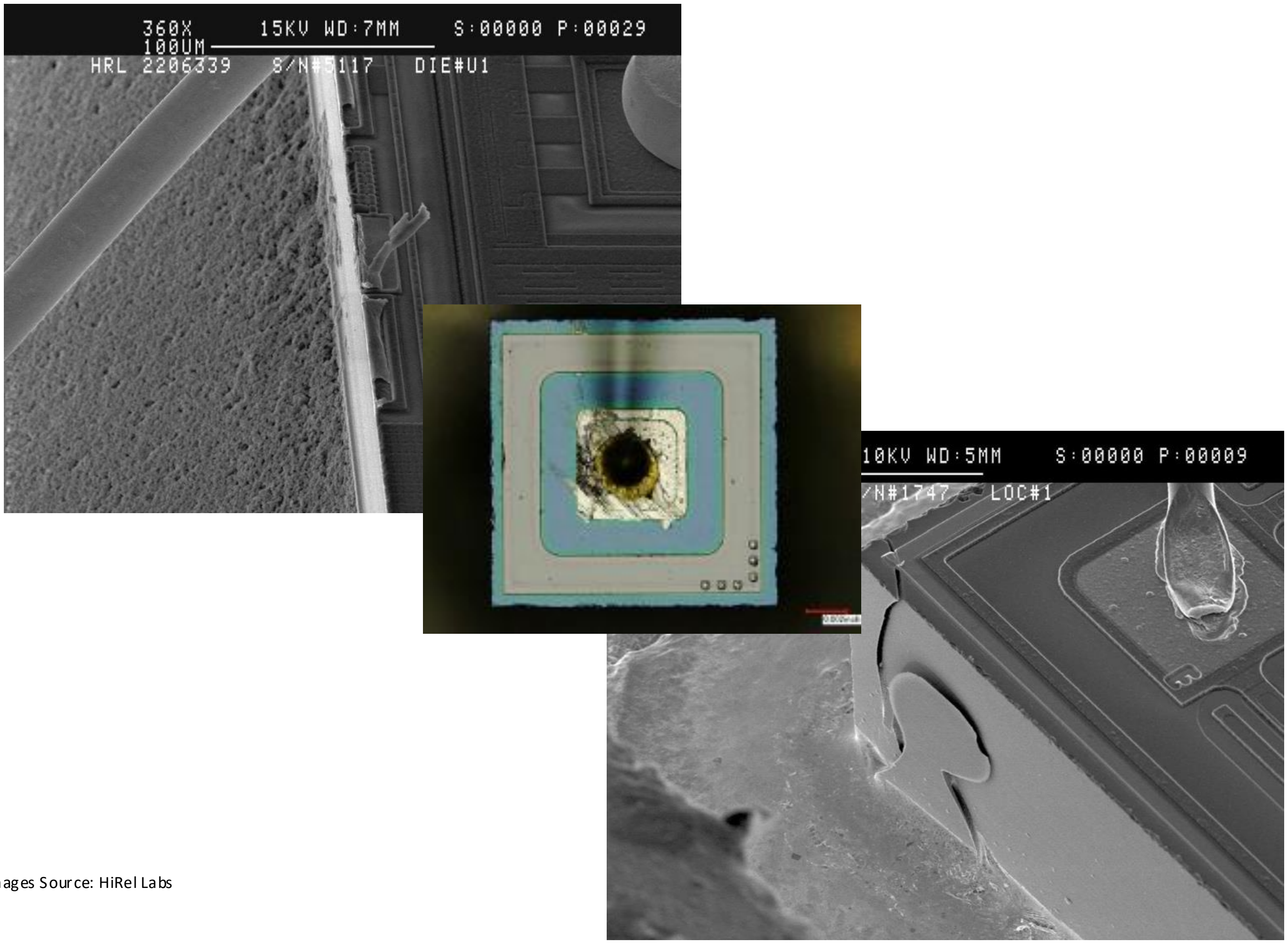
Bonds Over Non-common Metal





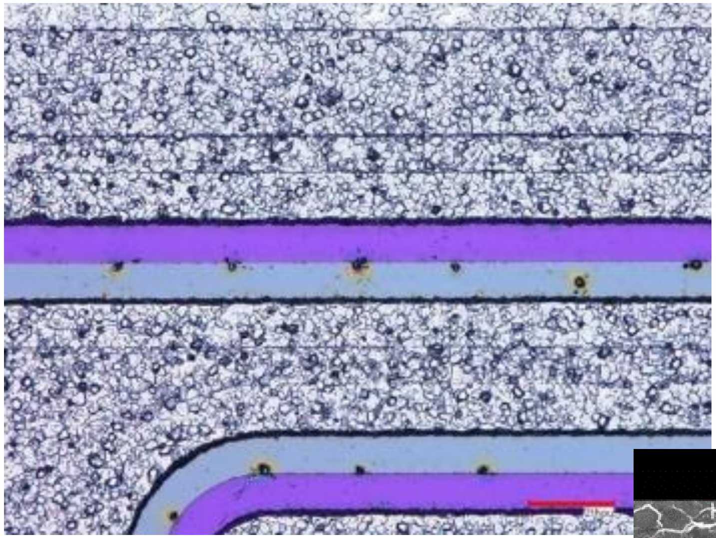
Images Source: HiRel Labs

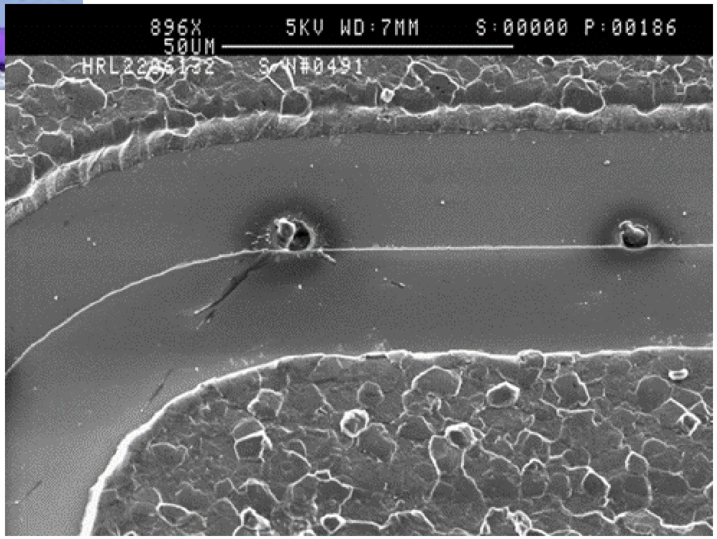
Dicing and Packaging Damage



Images Source: HiRel Labs

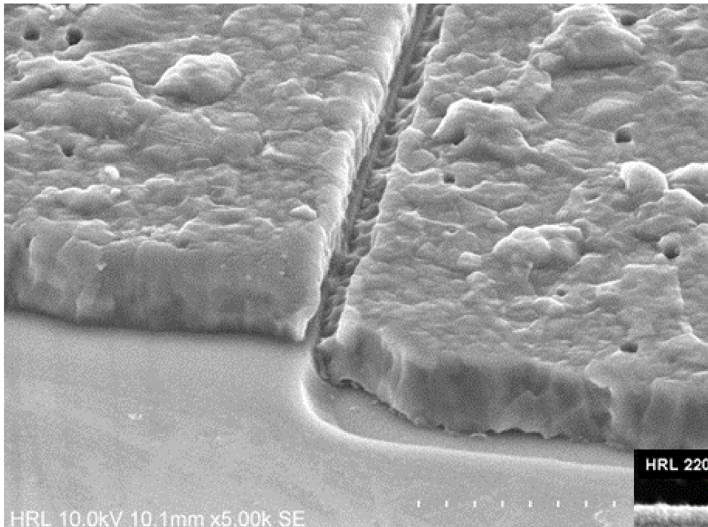
Electrical Test Damage

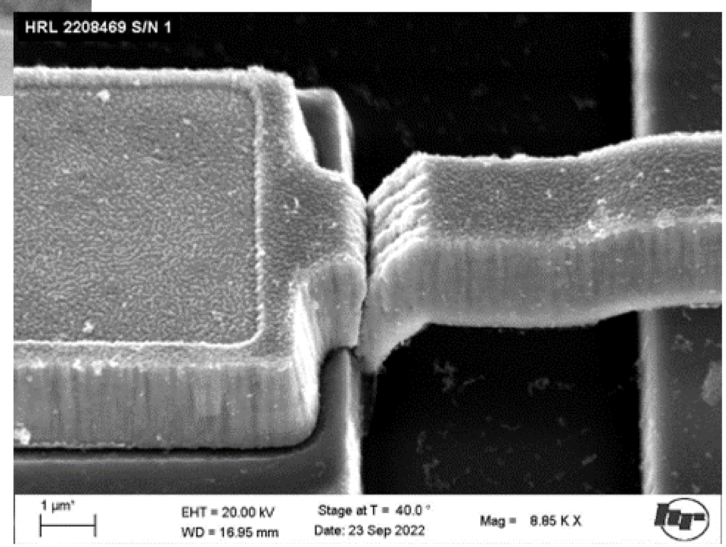




Images Source: HiRel Labs

Poor Step Coverage





Images Source: HiRel Labs

DPA Counterfeit Parts
Caveat Emptor!!!

Matryoshka* Capacitors?

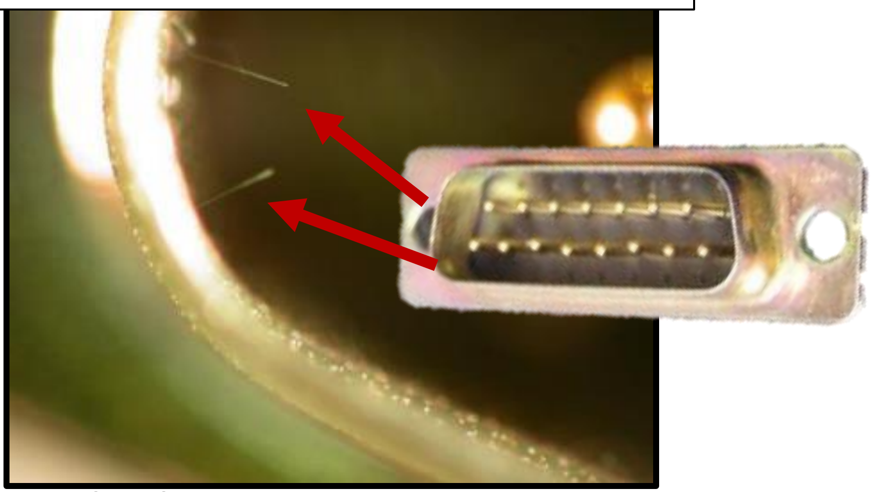
*A **matryoshka doll**, also known as a **Russian nested doll** or a **babushka doll**, is a set of dolls of decreasing sizes placed one inside the other.
Wikipedia

MIL-STD-1580 Section 9
Prohibited Materials Analysis

The following materials are prohibited due to *metal whisker formation* (Sn, Zn and Cd) and *sublimation/outgassing* (Cd and Zn):

1. **Tin (Sn)**
   Sn Surface finishes or Sn-based alloys *UNLESS alloyed with > 3% lead (Pb) by weight*
2. **Cadmium (Cd)**
   Cd surface finishes and Cd-containing materials with > 5% Cd by weight
   UNLESS overplated with nickel (Ni) or copper (Cu) of customer-approved thickness
3. **Zinc (Zn)**
   Zn surface finishes and *Zn-containing materials with > 5% Zn by weight*
   UNLESS overplated with nickel (Ni) or copper (Cu) of "customer-approved thickness"

Zinc Whiskers on Zn-Plated D-Sub Connector Shell
https://nepp.nasa.gov/whisker/photos/#dsub1



Customer Ordered Connectors with Ni-finish.
However, parts shipped with Cd-finish (yellow chromate).
P/N markings indicated "Ni-finish"