"Overview of Real Time X-ray "
Training Track 6 at ERAI/IHS Conference 2012

Andrew Buchan (Electronics Engineer)

Dynamic Research and Testing Laboratories, LLC

Dynamic Research and Testing Laboratories, LLC is located in Albuquerque New Mexico. The Laboratory is within the Electronic Contract Manufacturer "IEC Electronics Corp"

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Dynamic Research and Testing Laboratories, LLC

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Internal Auditor

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(Shared Resource)
Doc Control Administrator

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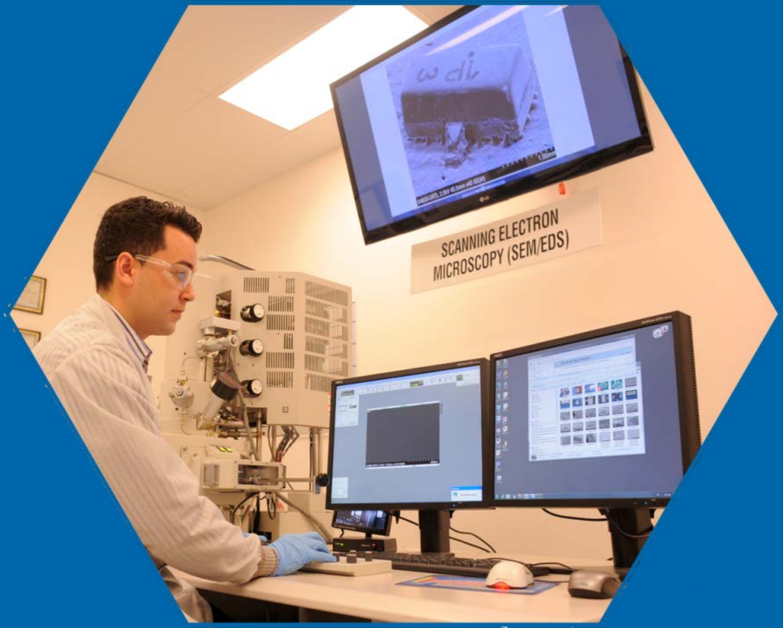
DRTL Capabilities

Dynamic Research and Testing Laboratories (DRTL)

- Component Risk Mitigation
- Destructive Physical Analysis
- Failure Analysis
- Parts Screening
- Product Qualifications
- Material Qualifications
- Consulting Services



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Overview

1) Explain why Real Time X-ray has become an integral part of a counterfeit avoidance inspection process
2) Provide evidence of Real Time X-ray being used to identify suspect counterfeit parts
3) Discuss challenges associated with device verification in Real Time X-ray.
4) Offer guidance relative to what to do when Real Time X-ray cannot be compared to the manufacturer's datasheet.
5) Outline the significance or insignificance of having a "golden sample " for comparative purposes
6) Explain when and if Real Time X-ray can or cannot accurately conclude if a part is or is not counterfeit
7) Explain when OCM verification is required
8) Offer guidance relative to determining the minimum lot size to be tested
9) Offer guidance relative to selecting samples for test from a large lot
10) Provide guidance that will assist attendees in the avoidance of "false positive " or "false negative" Real Time X–ray interpretations

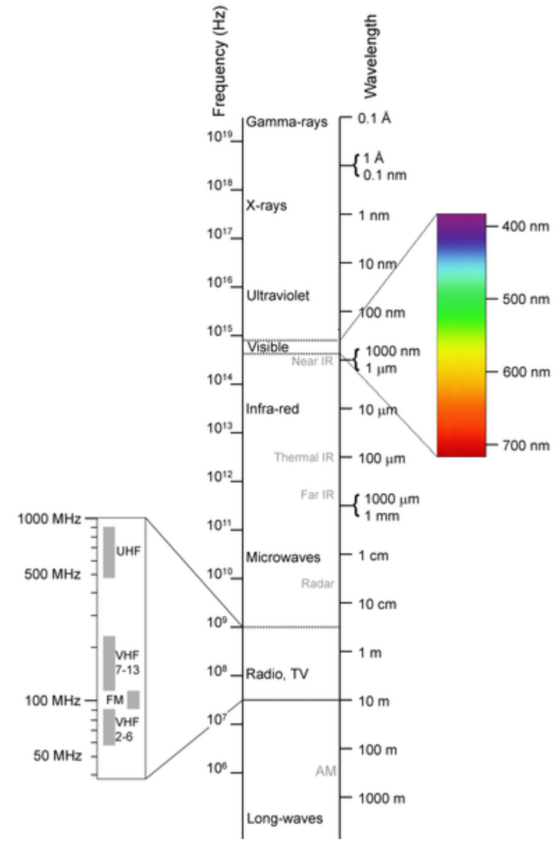
Real Time X-ray

Definition

➢ Radiography is the use of X-rays to view a non-uniformly composed material such as the electronic components. By using the physical properties of the ray an image can be developed which displays areas of different density and composition.

➢ X-radiation (composed of X-rays) is a form of electromagnetic radiation.

➢ A computer assisted reconstruction is used to generate a Real – time 2 or 3D representation of the scanned object.



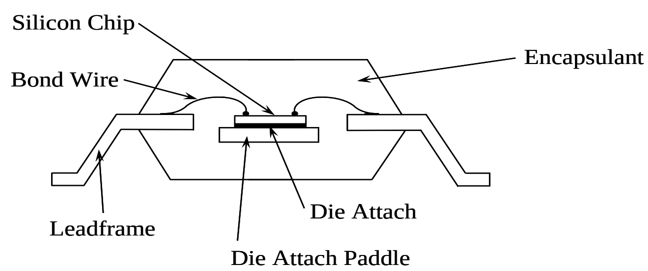
SAE AS5553 G-19 X-ray Sub-group

- **PURPOSE** - The purpose of radiology for suspect counterfeit part inspection is to detect deliberate misrepresentation of a part, either at the part distributor or OEM level. Radiological inspection can also potentially detect unintentional damage to the part resulting from improper removal of part from assemblies, which may include, but not limited to, prolonged elevated temperature exposure during desoldering operations or mechanical stresses during removal. Radiological inspection can also be used to detect defects induced during the manufacturing processes or to detect the effects of EOS/ESD damage.

SAE AS5553 G-19 X-ray Sub-group (Intro.)

Introduction …comparisons should be made within a homogenous sample population using the technical data available for that item. While evaluating electronic components with the same date code, part number, and place of manufacturing, a successful radiographic inspection for counterfeit part inspection **shall** require positive answers to the following questions:

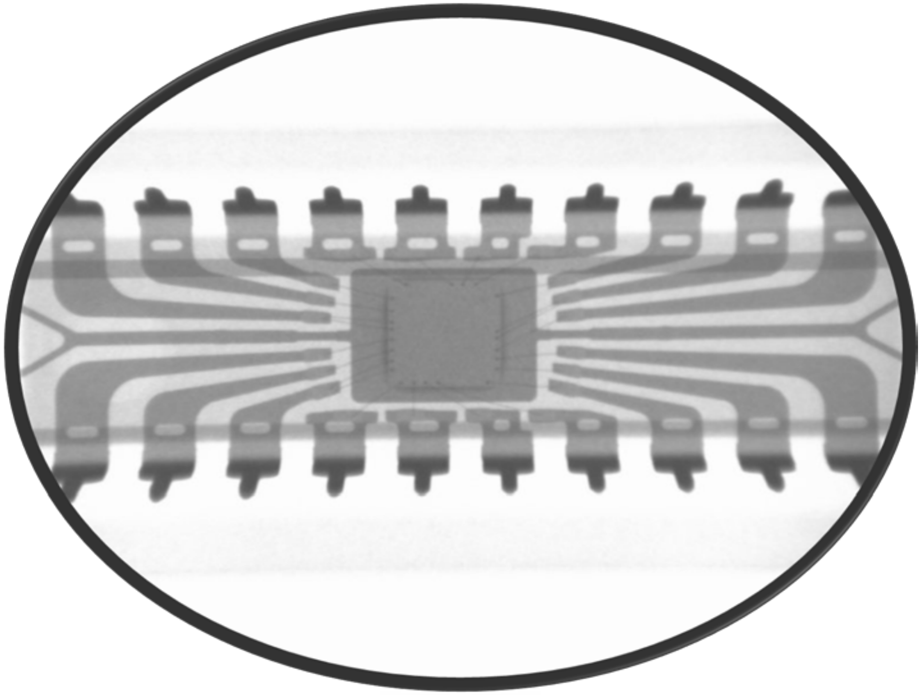
1. Are all the dies present and of the consistent correct size?
2. Is the general shape and structure of the package similar to the known authentic part?
3. Is the general shape and structure of the package similar to the other parts within the same lot?
4. Is the lead-frame construction homogenous?
5. Is there a homogenous wire bond gauge?
6. Are the number and position of wire bonds homogenous?
   - Is there any evidence of internal damage?
   - Excessive or unacceptable die attach voiding
   - Are wire-bonds present and intact?
   - Is there evidence of die tilt?
   - Is there any evidence of die cracking?
   - Is there any evidence of lead frame damage?
8. In side-view orientation, are the die and package thicknesses consistent within the lot?
9. Is there any other evidence that the parts have been altered or tampered with?



SAE AS5553 G-19 X-ray Sub-group (Cert.)

Apparatus/Certification/Qualification/Calibration:

- All procedures for the training for the operation of any given radiological system and the interpretation of the information displayed by the system **shall** be documented in the quality management system (QMS) of the facility utilizing the equipment.
- Periodic recalibration of any given radiographic system is required.
- Most systems will require preventative maintenance, which **shall** be accomplished per the equipment manufacturers' recommendations.
- Training to prepare the operator on how to interpret what is being displayed by the radiographic system can come from several sources. All radiological personnel **shall** be qualified (trained) and certified in the technique per a nationally accepted standard or equivalent, if such a standard is available



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SAE AS5553 G-19 X-ray Sub-group (Data)

Data from the Customer

1. Statement of work.
   - Number of parts being tested
   - Test procedure
2. Part datasheet or specification document.
3. Radiation tolerance of the parts being inspected.
4. Is an exemplar radiograph or part being provided for comparison? The minimum requirements for an exemplar radiograph or part shall include identical:
   - Part number
   - Lot code
   - Date code
   - Manufacturing site
   - External markings
   - Component packaging
5. How are the parts packaged? Example: tube, reel or bag.

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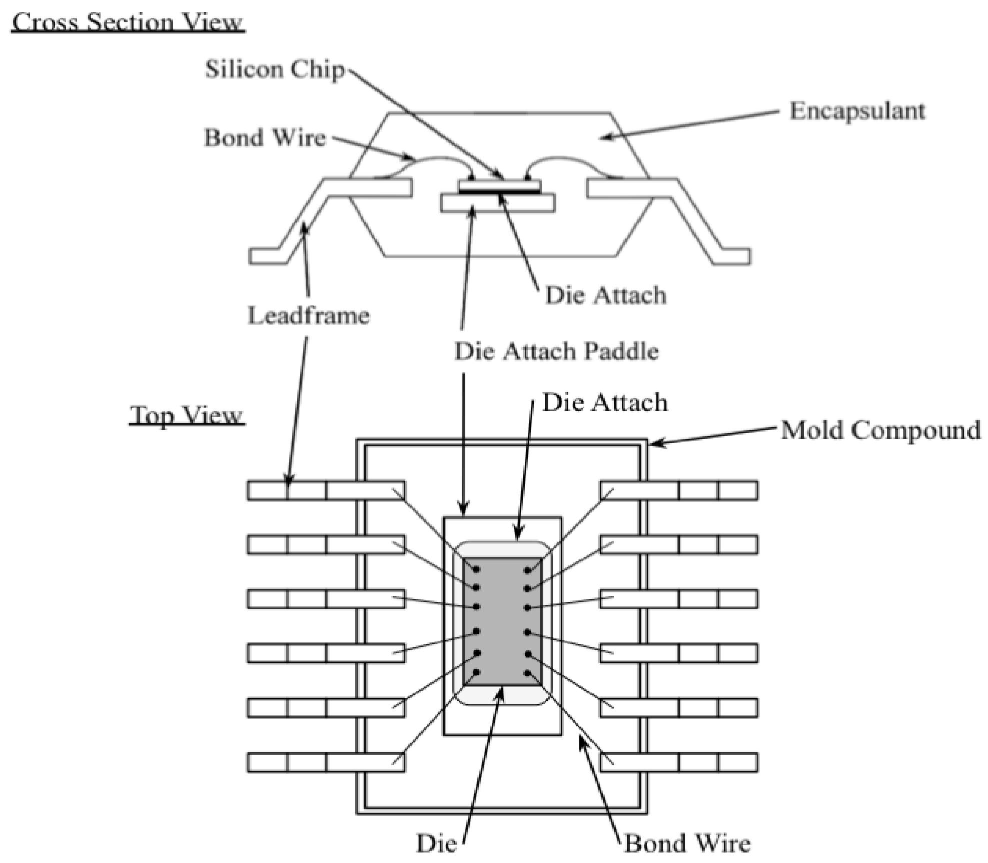
SAE AS5553 G-19 X-ray Sub-group (Cust/Data)

Data to Customer

A report on radiological inspection of part authentication **shall** include the following details. A sample report is shown in appendix A.

1. Number of parts inspected.
2. Number of parts in the lot.
3. Date code or lot code of the parts.
4. X-ray parameters used for each part Key findings (kV, uA etc.).
5. Availability or non-availability of a known good part.
6. If the device cannot be inspected due to package design (ex. flat-pack with heat sink or spacer at base of package).
7. When parts of the device cannot be clearly seen due to opacity of construction materials or case design.
8. Any key differences observed between a device under test and known good part. Information on a known good part or "Golden part"(when available).
9. If die mask layout information is available from die manufacturer, then a radiological image of the suspect part can be overlaid on the mask for comparison. Differences observed between the two, if any, should be recorded and included in the final report.
10. Radiological Data Management (TIFF or DICONDE format).

SAE AS5553 G-19 X-ray Sub-group (Sample Insp.)

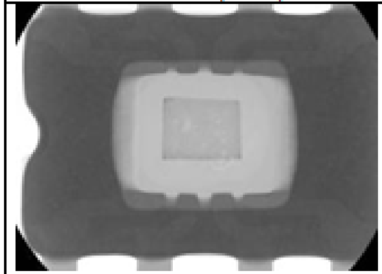


SAE AS5553 G-19 X-ray Sub-group (Sample Insp.)

Inspection Results

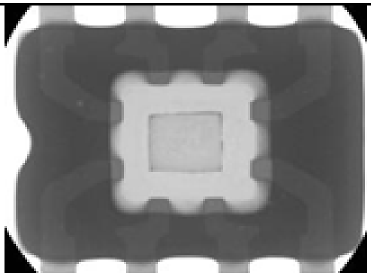
TelCom TSC4428MJA

DC8851 Lead Frame (Part 4)



79KV 83µA 65x

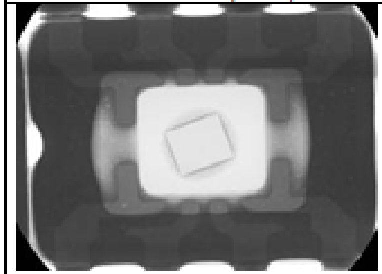
DC9002 Lead Frame



80KV 91µA 65x

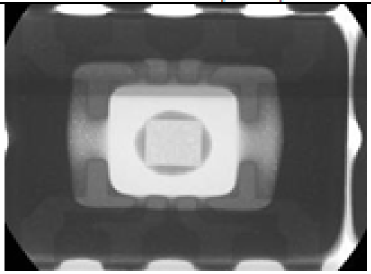
OBSERVATION (S): Wire frame different in layout.

Die Overview DC9201 (Part 1)



85KV 55µA 65x

Die Overview DC9201 (Part 3)

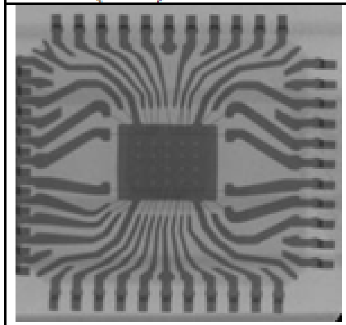


85KV 55µA 65x

OBSERVATION (S): Die is rotated 45° and Different Die Frame layout

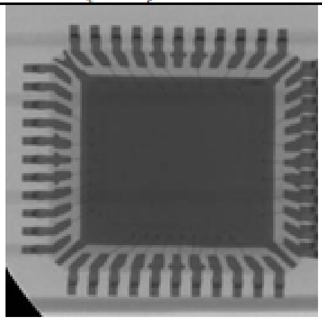
Xilinx XC18V02VQ44I

Die Size (Part 2)



67KV 65µA 40x

Die Size (Part 4)



67KV 65µA 35x

Report Number: 2011070055 July 21, 2011

Fig 5: S/N 1 X-View

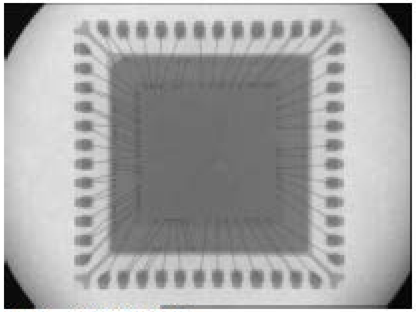


Fig 6: S/N 1 Y-View

Fig 7: S/N 2 X-View

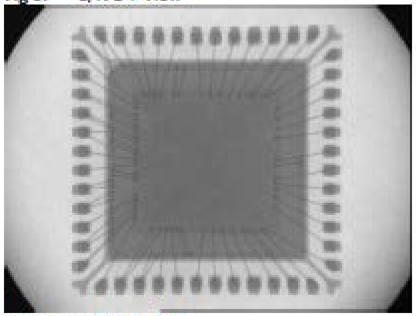


Fig 8: S/N 2 Y-View

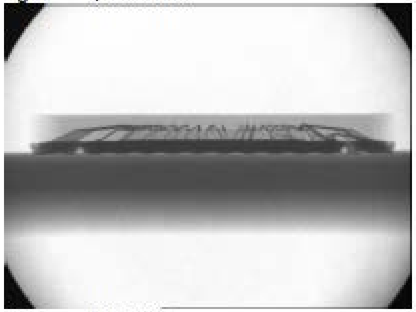


Fig 9: S/N 3 X-View

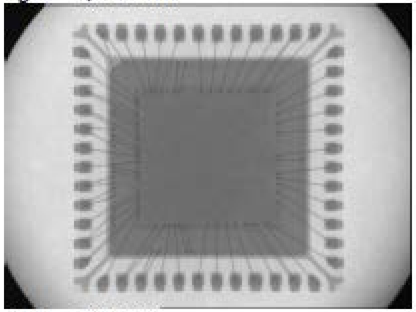


Fig 10: S/N 3 Y-View

SAE AS5553 G-19 X-ray Sub-group (FAQS)

Frequently Asked Questions

1. Can I detect semiconductor die marks using radiological inspection?
2. Are radiological inspection systems safe to use? Considering health effects, dosimetery requirements and operator safety.
3. How often should the radiological system be serviced?
4. Are there local, state or federal regulations that govern installation, use and operation of radiological systems?
5. Is Real Time X-ray 2D, 3D, 5Dx required for counterfeit detection?

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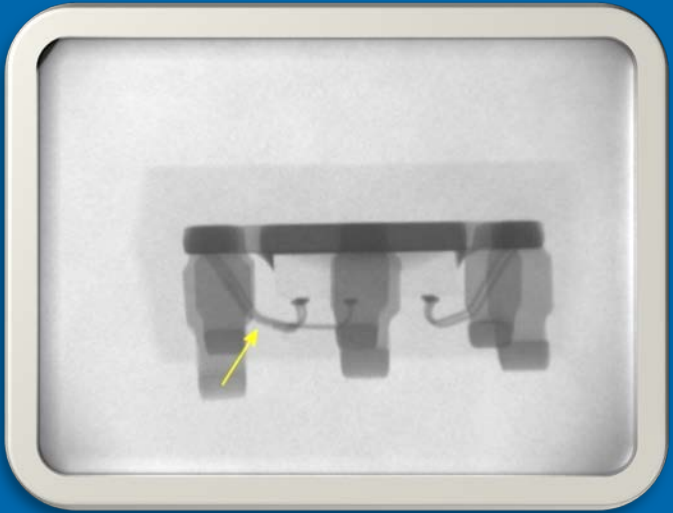
X-ray to Facilitate De-Cap and CSAM

- Real time x-ray system
- Three axis x-ray images recorded
- Package Examples
  - Transistor Outline (TO)
  - Ceramic Devices (Metal Lid?)
  - Plastic Parts
  - Resistors
  - Capacitors
  - Transformers
  - Filters
  - Etc.



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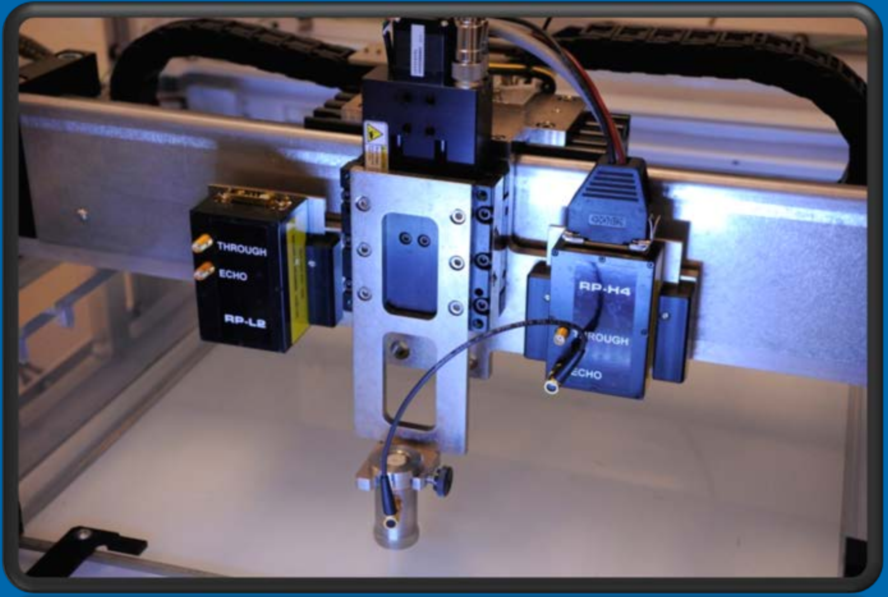
CSAM to Facilitate X-ray

- Scanning Acoustic Microscopy (CSAM)
- Transmitted or Reflected?
- Package Examples
    - Plastic Parts
    - Resistors
    - Capacitors
    - Transformers
    - Filters
    - Etc.



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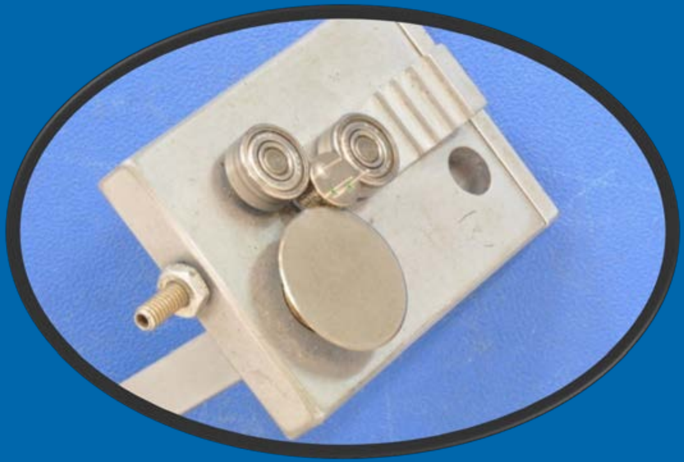
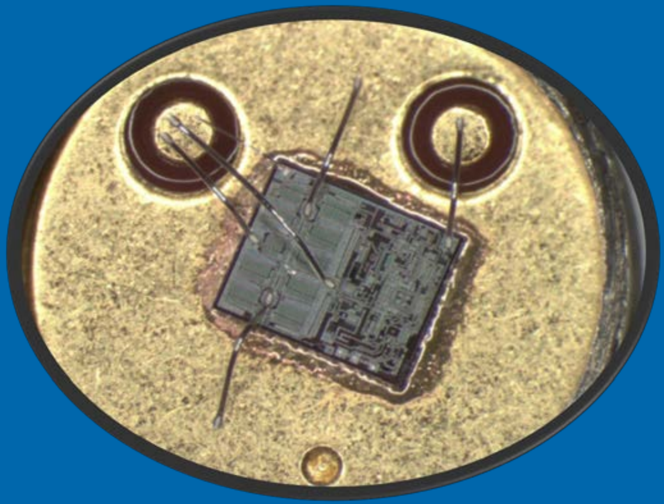
Mechanical De-Cap

- Delidding and/or decapping are examples of mechanical de-cap
- Transistor outline (TO) package requires the lid removal via cutting of metal lid or weld





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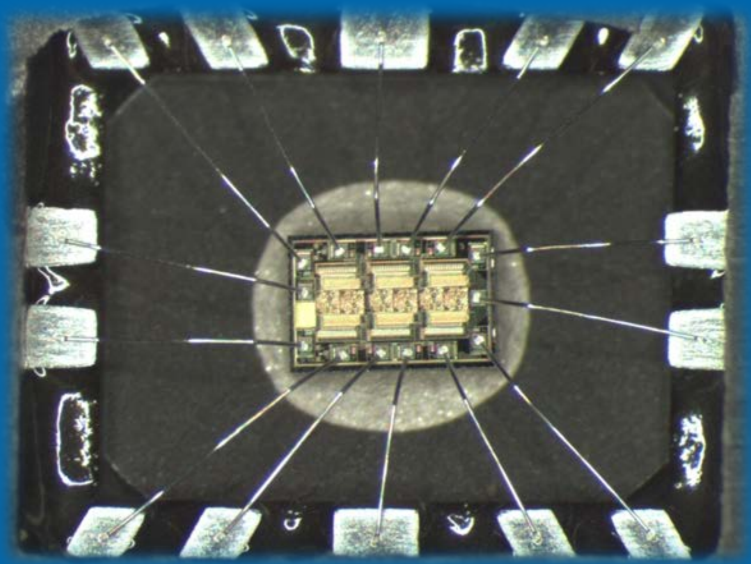
Mechanical De-Cap

- Delidding and/or decapping are examples of mechanical de-cap
- Ceramic DIP packages require to break the seal glass, or the cutting of the weld around a metal lid



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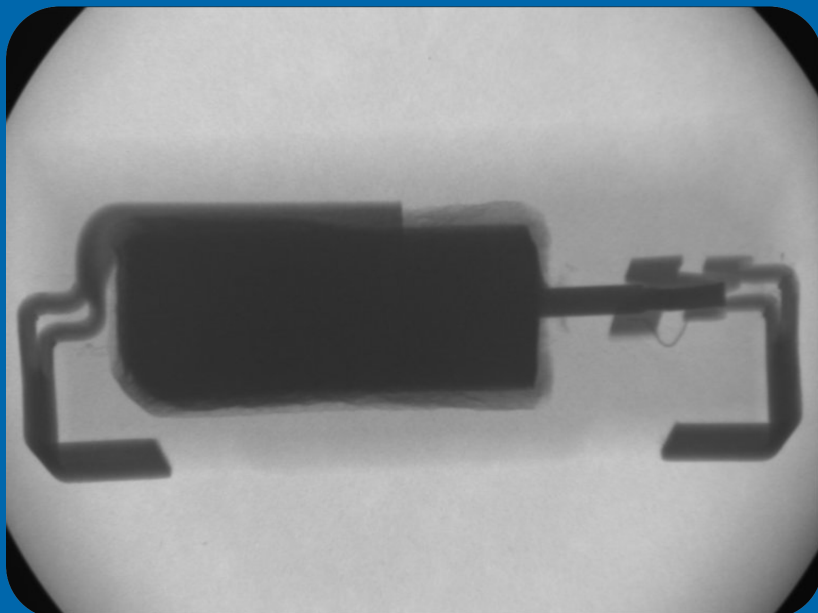
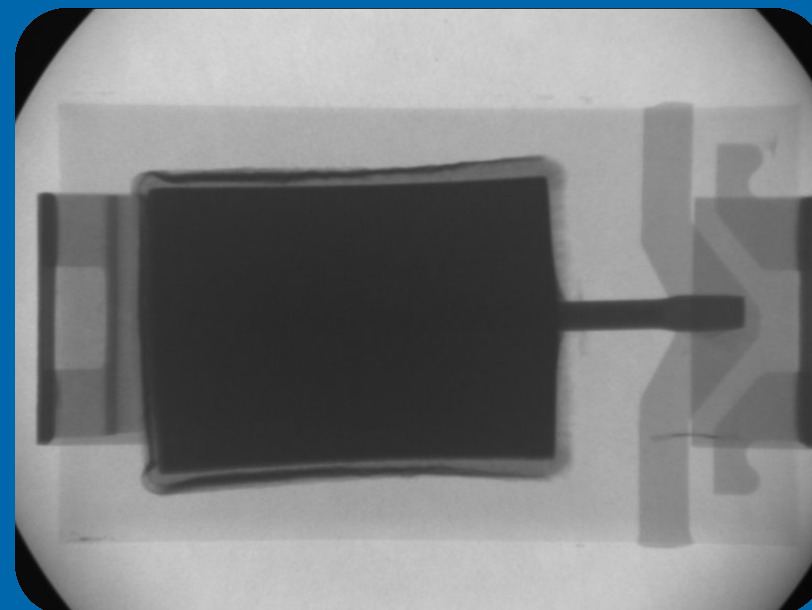
Real Time X-ray Examples





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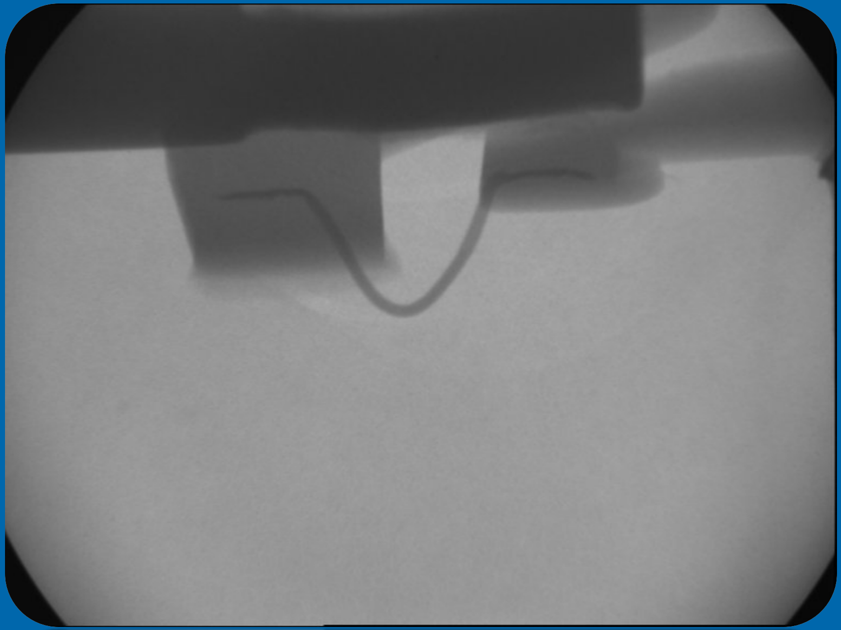
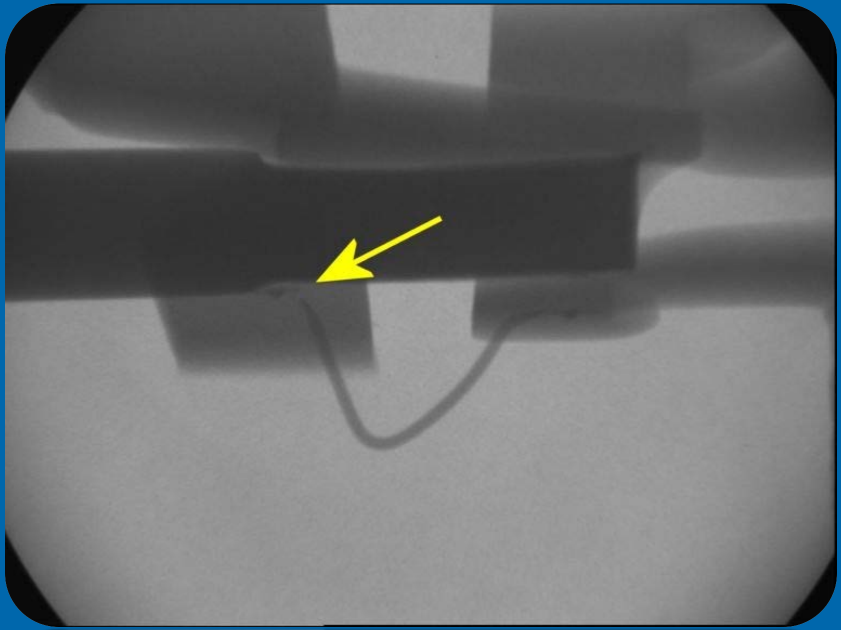
Real Time X-ray Examples





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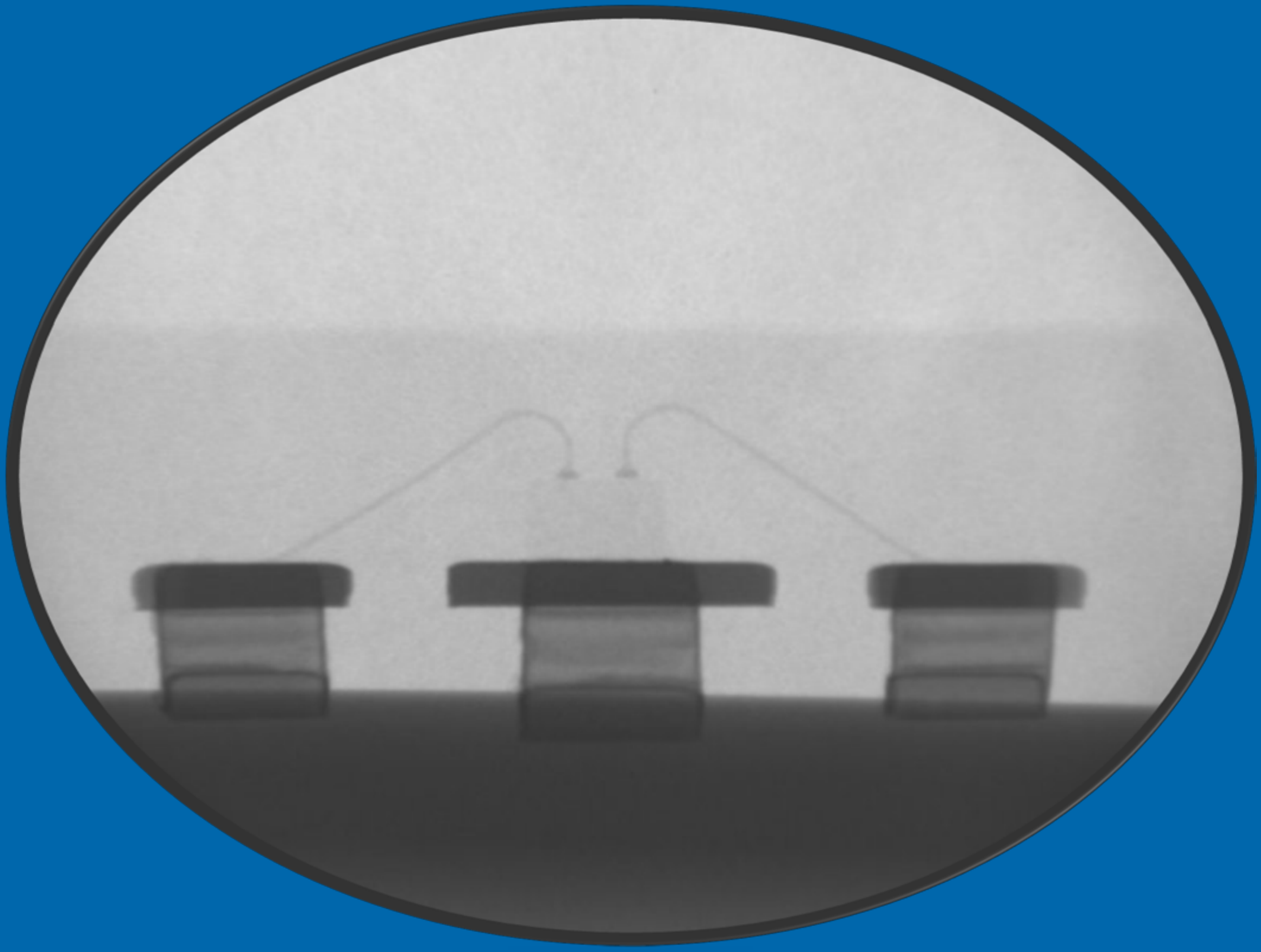
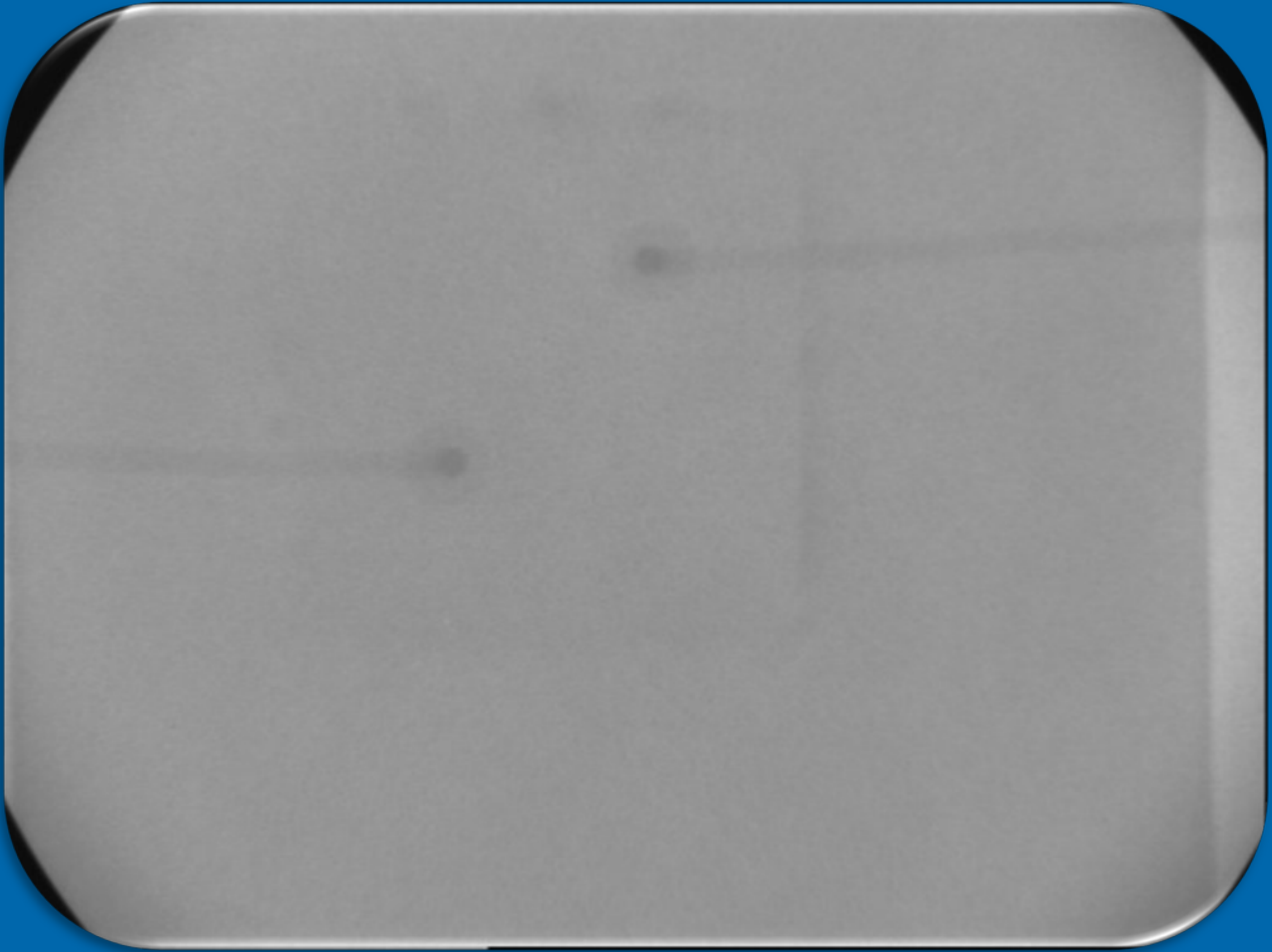
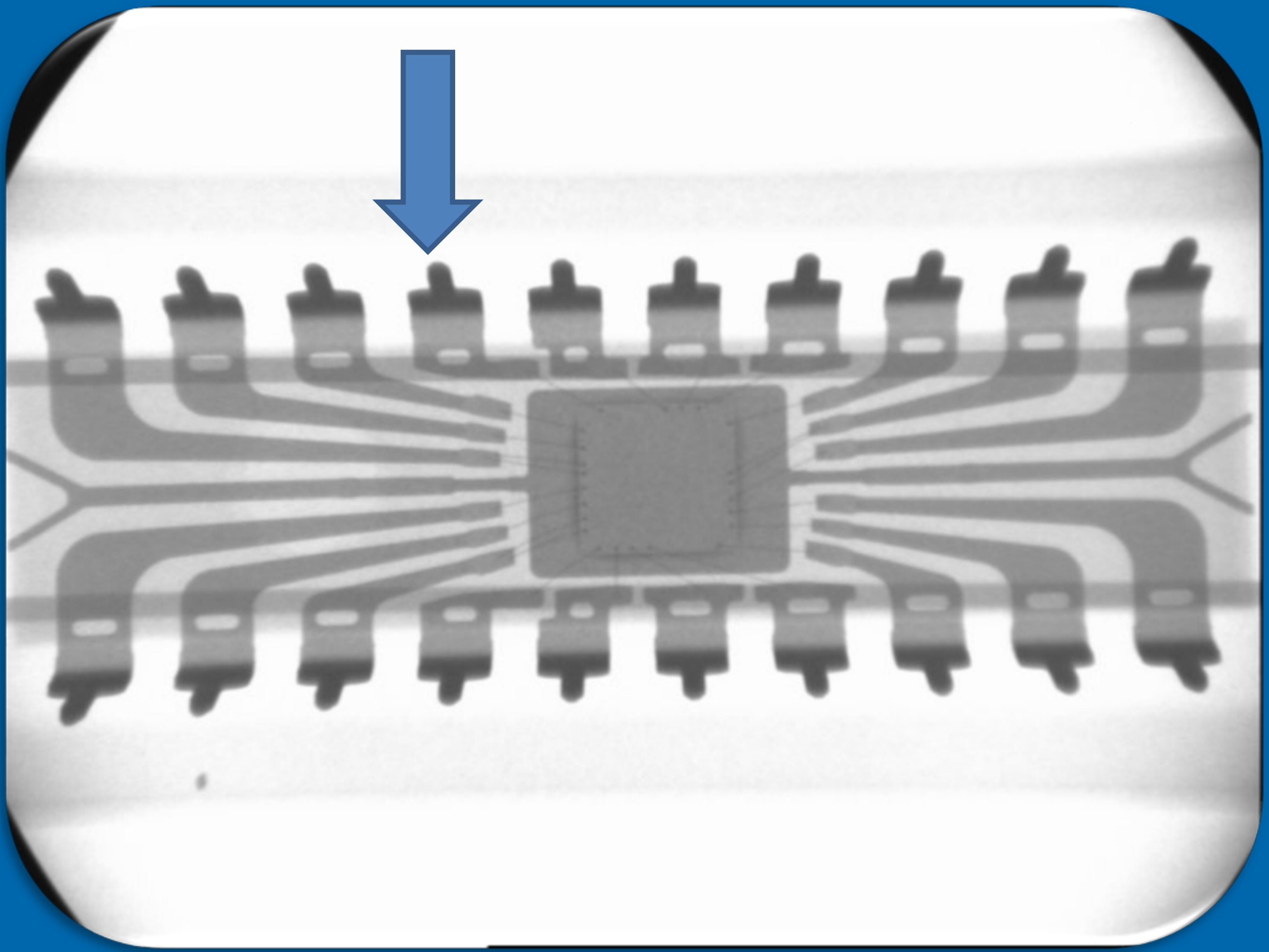
Real Time X-ray Examples



Real Time X-ray Examples



Real Time X-ray Examples



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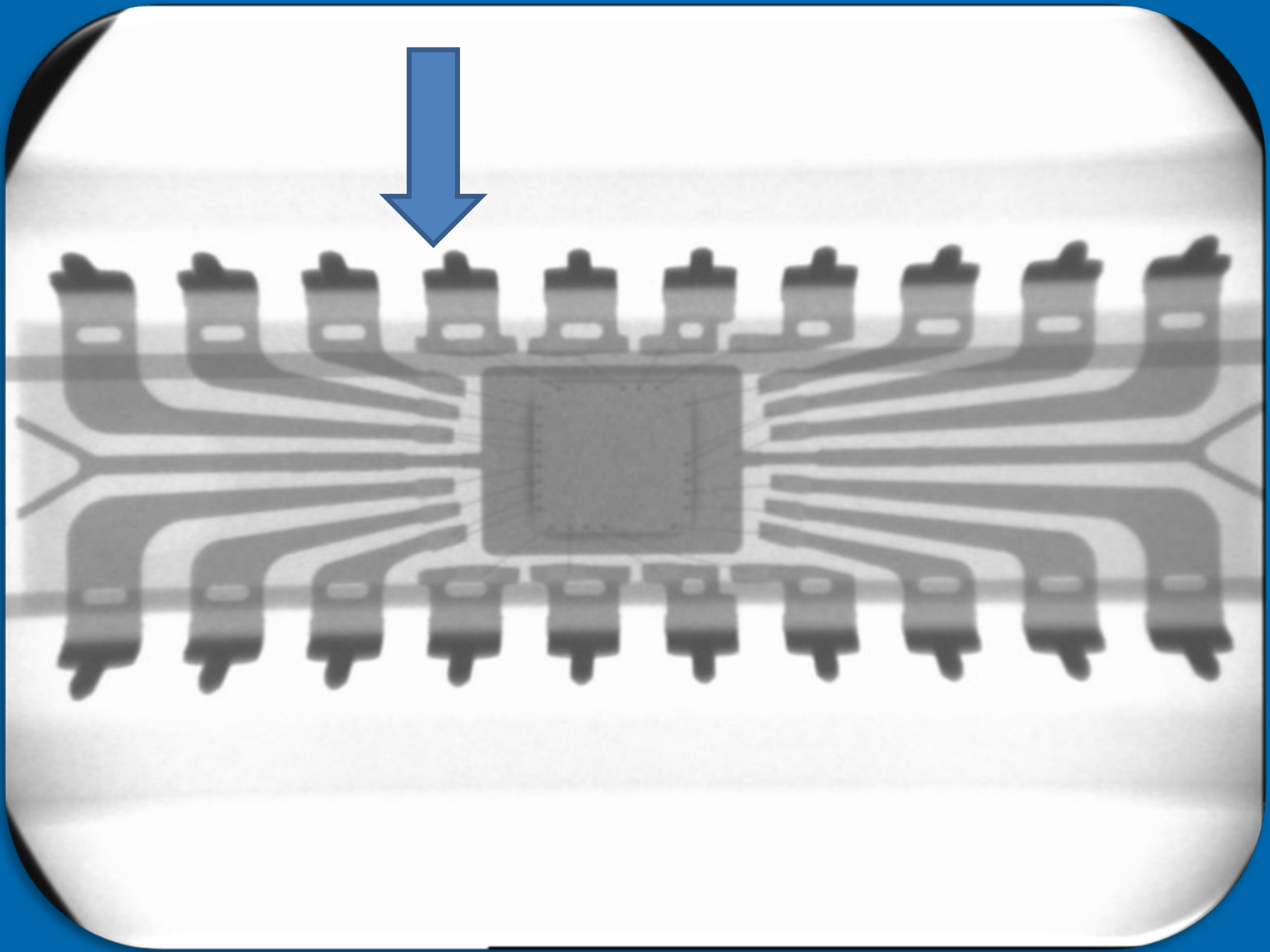
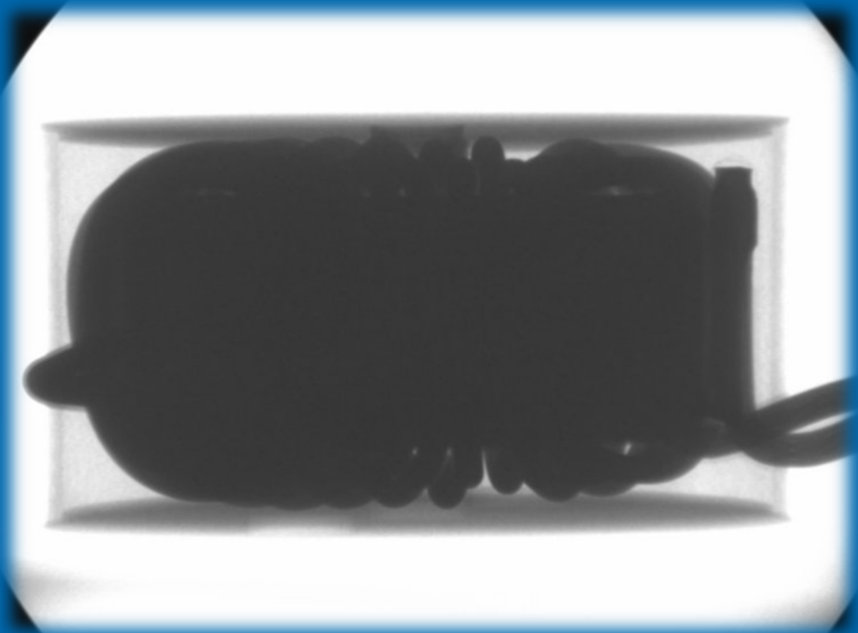
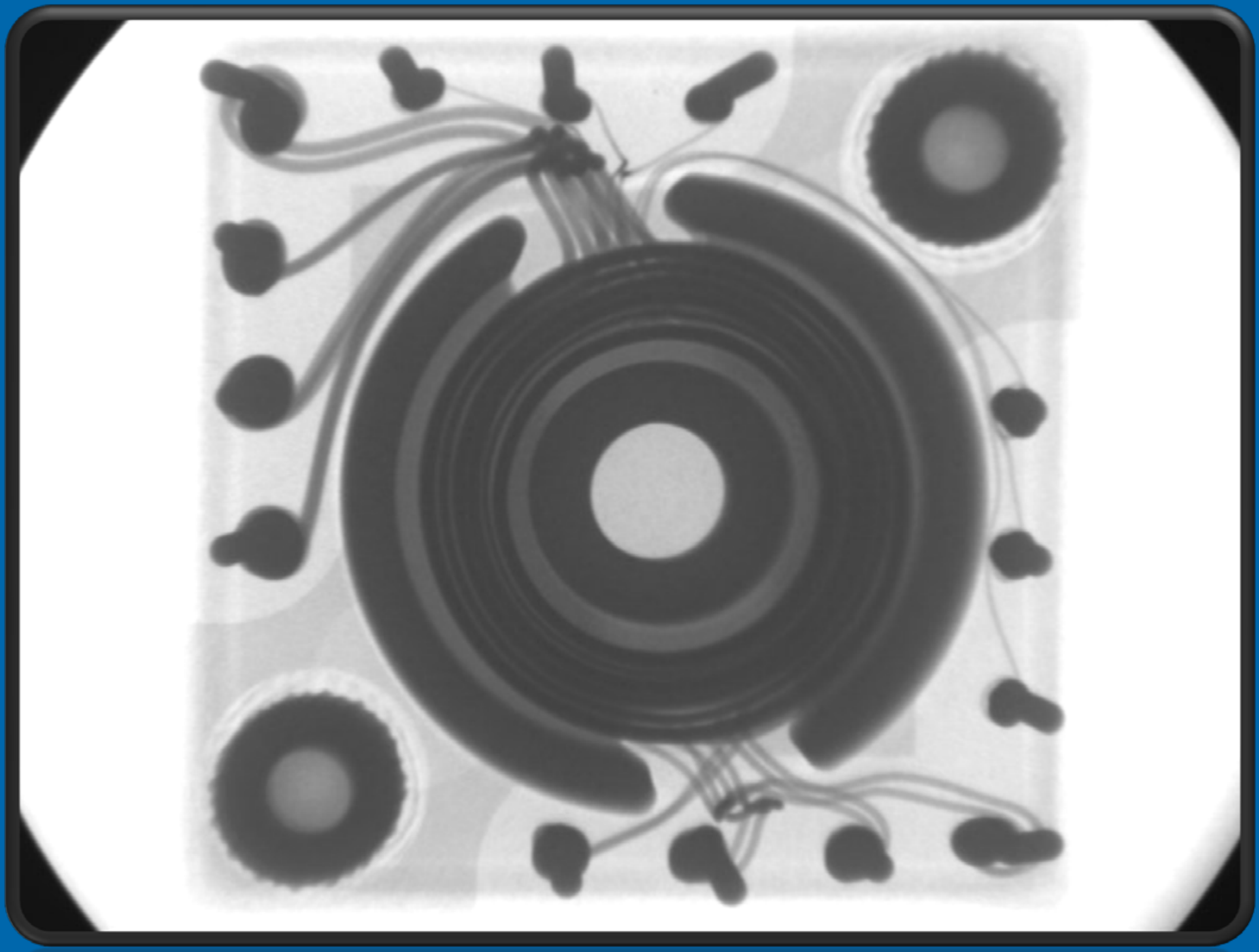
Real Time X-ray Examples



Real Time X-ray Examples



Real Time X-ray Examples



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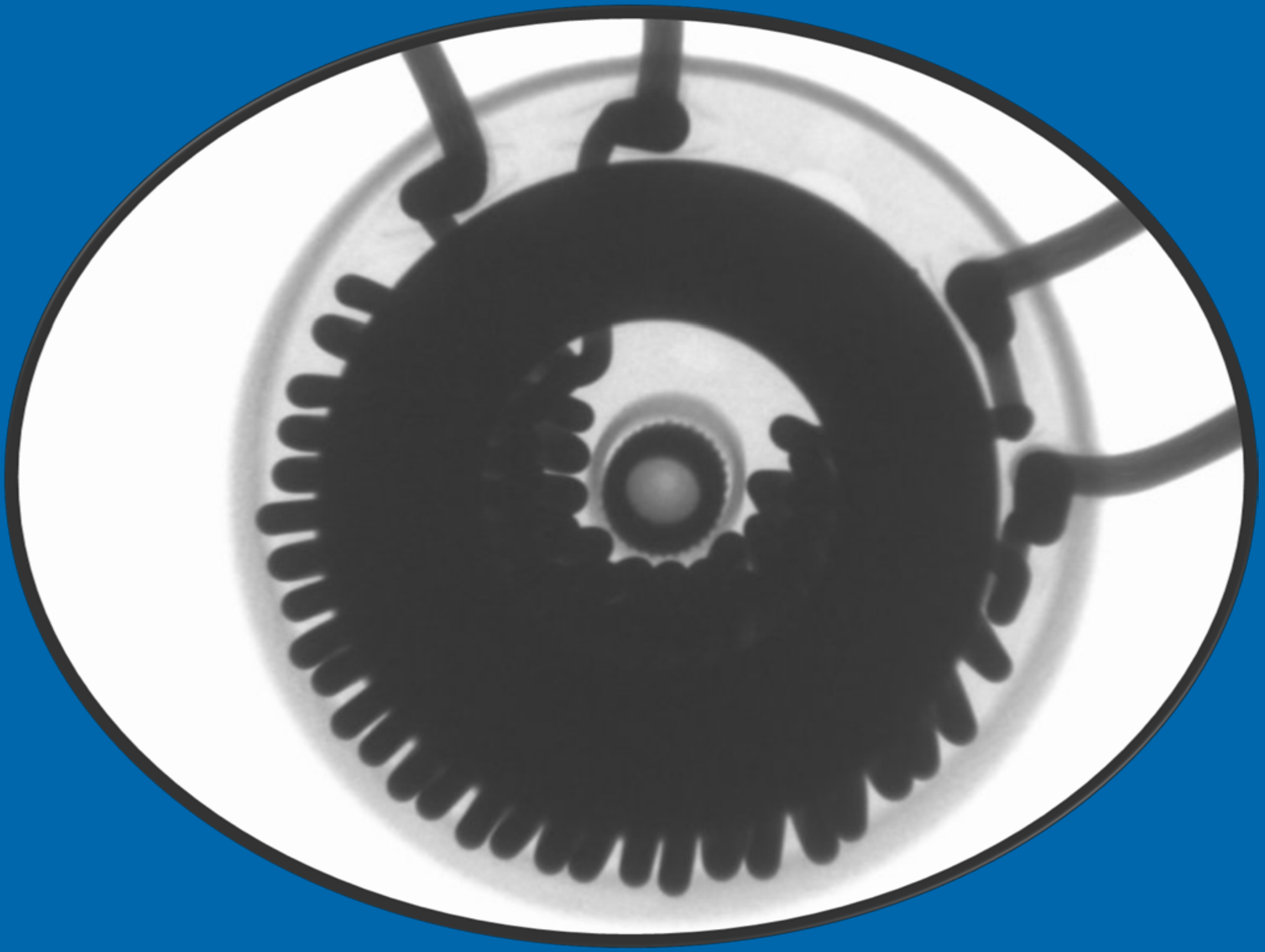
Real Time X-ray Examples



SAE AS5553 G-19 X-ray Sub-group (RISK?)

TABLE 3.4.1 ACTIVE DEVICES CP DETECTION FLOW, Rev1
(microcircuits & semiconductor devices)

Steps	Mechanical/Environmental/Electrical Inspections/Tests	4 Critical Risk	3 High Risk	2 Moderate Risk	1 Low Risk	0 Very Low Risk
1	External visual Inspection, EVIG (General, Full Lot)	Y	Y	Y	Y	Y
2	External visual Inspection, EVID (Detailed, Sample)	Y	Y	Y	Y	Y
3	Remarking & Resurfacing, p/o EVI Inspection	Y	Y	Y	Y	Y
4	XRF	Y	Y	Y	Y	Y
5	Delid Physical Analysis	Y	Y	Y	Y	
6	Radiological/X-RAY	Y	Y	Y	Y	
7	Acoustic Microscopy (AM)	Y	Y	Y	Y	
8	Miscellaneous	AN	AN	AN	AN	
9	Seal (hermetic devices)	Y	Y	Y	Y	

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ISO 17025 Field of Tests

Scope of Accreditation to ISO/IEC 17025:2005

FIELD OF TEST	SPECIFIC TESTS OR PROPERTIES MEASURED	SPECIFICATION, STANDARD METHOD OR TECHNIQUE USED	*DETECTION LIMIT/ RANGE/ EQUIPMENT
Non-Destructive Testing (NDT)	Elemental content by XRF (Lead, tin, etc.)	JESD213	Fischerscope XDAL
Non-Destructive Testing (NDT)	Radiographic Examination / Inspection	MIL-STD-883, Method 2012 MIL-STD-750, Method 2076 MIL-STD-202, Method 209	X-TEK Model: Orbita
Non-Destructive Testing (NDT)	Acoustic Microscopy (CSAM) Examination / Inspection	IPC/JEDEC, J-STD-035	Sonix Echo
Mechanical	SEM Examination / Inspection	MIL-STD-750, Method 2077 MIL-STD-883, Method 2018	Hitachi S-4800
Mechanical	Internal Examination / Inspection	MIL-STD-883, Method 2010 and 2013 MIL-STD-750 Method 2072	Olympus BX50
Mechanical	Particle Impact Noise Detection (PIND)	MIL-STD-883, Method 2020 MIL-STD-750, Method 2052	Spectral Dynamics PTI Model: 4511 I
Mechanical	Die Shear Grams of Force	MIL-STD-883, Method 2019 MIL-STD-750, Method 2017	Dage 4000

http://www.DRTLonline.com

ISO 17025 Skill Set Model

Skill Set Model

Note: Instruction-related review / training includes the related:
TSTI = Instructions
TSTC = Checklists

Competency

Experience:	EXP
Training Class:	TRC
On the Job Training	OJT
Observation:	OBS
Test:	TST
Education:	EDU

Evaluator

Clifton Aldridge	CA
[Name]	Initials
[Name]	Initials
Mark Northrup	MRN
Chris Hoover	CH
Instructor	INS

Color Key

Pending Skill Training
Completed Skill Training
LATE Skill Training

Process	Andy Buchan Device Engineer				Ra… De…							
	Planned	Eval. Method	Evaluator	Completed	Planned	…hod	…tor	…ed				
TSTP-001, Testing Process	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-001, SEM Examination	11/30/11	OJT	CA	11/30/11	1/30/12							
TSTI-002, Internal Examination	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-013, Olympus BX50 Leica MZ80 - Infinity Camera Operating Procedure	11/30/11	OJT	CA	1/24/12	8/2/11							
TSTI-004, Wire Bond and Die Shear Test Instructions	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-012, Wet Saw Operation	11/30/11	OJT	CA	1/20/12	8/2/11							
TSTI-014, Chemical Decapulation Instructions	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-015, Sample Mounting Instructions	1/24/12	OJT	CA	1/24/12	8/2/11							
TSTI-016, Solderability Testing	1/24/12	OJT	CA	1/24/12	6/15/12							
TSTI-005, XRF	1/24/12	EXP	CA	1/24/12	3/15/12							
TSTI-006, Radiographic / X-ray Examination	1/24/12	EXP	CA	1/24/12	8/2/11							
TSTI-007, PIND	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-008, Acoustic Microscopy	11/30/11	OJT	CA	11/30/11	8/2/11							
TSTI-009, Seal Test Operation	1/24/12	OJT	CA	1/24/12	8/2/11	TRC	CA	8/2/11	6/15/12	TRC	CA	Pending
TSTI-017, External Inspection of Devices	1/24/12	OJT	CA	1/24/12	8/2/11	TRC	CA	8/2/11	6/15/12	TRC	CA	Pending

Dynamic Research and Testing Laboratories – Business Instruction

DYNAMIC RESEARCH AND TESTING LABORATORIES, LLC DRTL	***Document Title:*** **Radiographic / X-Ray Examination** ***Document Number:*** **TSTI-006, Rev. B**
Document Owner: **Rachel Garcia** ***Backup Owner:*** **Clifton Aldridge**	***Approver(s):*** **Clifton Aldridge**
Parent Document: **TSTP-001, Testing Process**	***Notify of Changes:*** **All Dynamic Research and Testing Laboratories Employees**

Referenced Document(s):
TSTC-006 Radiographic Inspection - Discretes; TSTC-007 Radiographic Inspection – ICs; TSTC-008 Radiographic Inspection – Passives; HRMF-004 Skill Set Model; DRTL Database; Orbita Manual 2004; MIL-STD-750 Method 2076, MIL-STD-883 Method 2012 , MIL-STD-202 Method 209; REG-003, Record Register

ERAI/IHS Membership

Counterfeit Part Analysis

We would all prefer to follow the standards of the U.S. Government Industry Data Exchange Program (AS5333 – Counterfeit Electronic Parts, Avoidance, Detection, Mitigation, and Disposition) or the Independent Distributors of Electronics Association (IDEA-STD-1010-A). Unfortunately, many of us cannot use an approved vendor due to long lifecycle product demands, requiring us to perform Component Risk Mitigation Testing Methodology. Our contention is that the term "Counterfeit Parts Analysis" is better served via a Component Risk Mitigation Test Plan by using existing Destructive Physical Failure, Construction, and Electrical Analysis practices.

Legislative Advocacy

DRTL is focused on addressing the most pressing issues facing today's procurement of electronic components. We are strong advocates of the U.S. governments' push on legislative changes to detect and avoid counterfeit parts leaking into our supply chain, as referenced in the National Defense Authorization Act for Fiscal Year 2012 (Sec. 818 – Detection and Avoidance of Counterfeit Electronic Parts, and Sec. 2320 – Trafficking in Counterfeit Goods or Services) and the recent Government Accountability Office Report (DoD Supply Chain – Suspect Counterfeit Parts Can Be Found on Internet Purchasing Platforms).

Summary

1) Explain why Real Time X-ray has become an integral part of a counterfeit avoidance inspection process
2) Provide evidence of Real Time X-ray being used to identify suspect counterfeit parts
3) Discuss challenges associated with device verification in Real Time X-ray.
4) Offer guidance relative to what to do when Real Time X-ray cannot be compared to the manufacturer's datasheet.
5) Outline the significance or insignificance of having a "golden sample " for comparative purposes
6) Explain when and if Real Time X-ray can or cannot accurately conclude if a part is or is not counterfeit
7) Explain when OCM verification is required
8) Offer guidance relative to determining the minimum lot size to be tested
9) Offer guidance relative to selecting samples for test from a large lot
10) Provide guidance that will assist attendees in the avoidance of "false positive " or "false negative" Real Time X–ray interpretations

ERAI & DRTL Team

Rachel Garcia - Dynamic Research and Testing Labs, LLC.

Rachel is a Component Analyst at Dynamic Research and Testing Laboratories (DRTL). She has 8 years of experience with Destructive Physical Analysis (DPA) and holds an A.A.S in Computer Electronics Engineering Technology from ITT Technical Institute in Albuquerque, NM. Rachel is currently a member of SAE G-19 Committee.

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Andrew Buchan - Dynamic Research and Testing Labs, LLC.

Andy is a Graduate from the Rochester Institute of Technology with a Bachelors of Science in Manufacturing Engineering Technology. He began his career in the Electronics industry at IEC Electronics holding a variety of roles including Manufacturing Engineering Technician, Materials Lab Technician, Materials Lab Engineer. Andy joined Dynamic Research and Testing Laboratories (DRTL) as an Electronics Engineer. With his experience in failure analysis of printed circuit board assemblies Andy brings a unique perspective to DRTL.

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Clifton Aldridge - Dynamic Research and Testing Labs, LLC.

Mr. Aldridge has over 20 years experience with significant aerospace companies. He also gained extensive senior management experience as vice president of Analytical Solutions, Inc. His background includes performing remote component test verification of devices in various radiation environments, construction and failure analysis of microelectronic devices and component engineering activities encompassing automated test development and part obsolescence management. Mr. Aldridge holds a Bachelors of Science degree in Electrical Engineering Technology from DeVry Institute of Technology in Kansas City, Missouri.

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Can You Afford Not To have A Risk Mitigation Strategy ?

Thank you !

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