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Lead-Free Inspection Methods

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Overview

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- Look at the solder!!
- ICP 610D
- Lead detection fluids
- Microsectioning & SEM
- X-ray inspection
- XRF (also detects Cd, Hg, Cr, Br)
- Conclusions & Questions

Which are lead-free?

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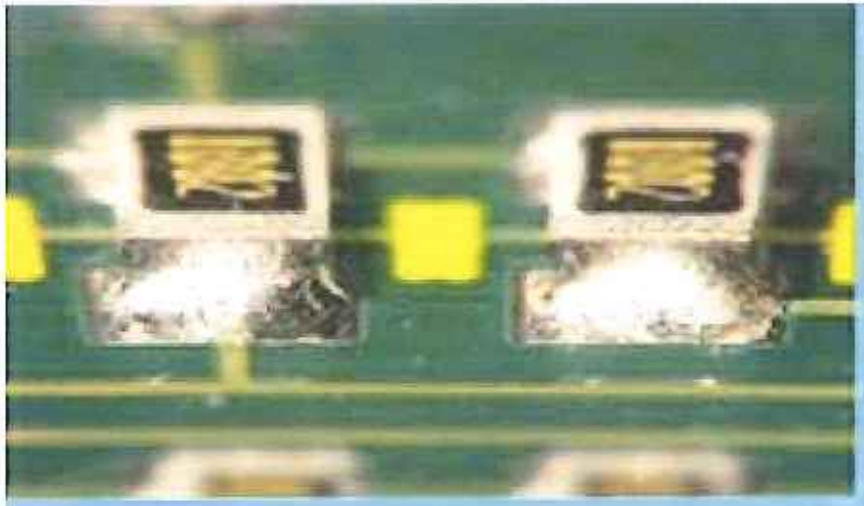

Look at the solder

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- Is the products labelled?
- Understand the codes for the alloys e.g. Sn/Pb, SAC, Sn/Bi, 305
- Feel the solder. Is it easy to bend?
- Lead-free solder paste often has a slight greenish appearance in the jar.

Different ways of saying lead-free

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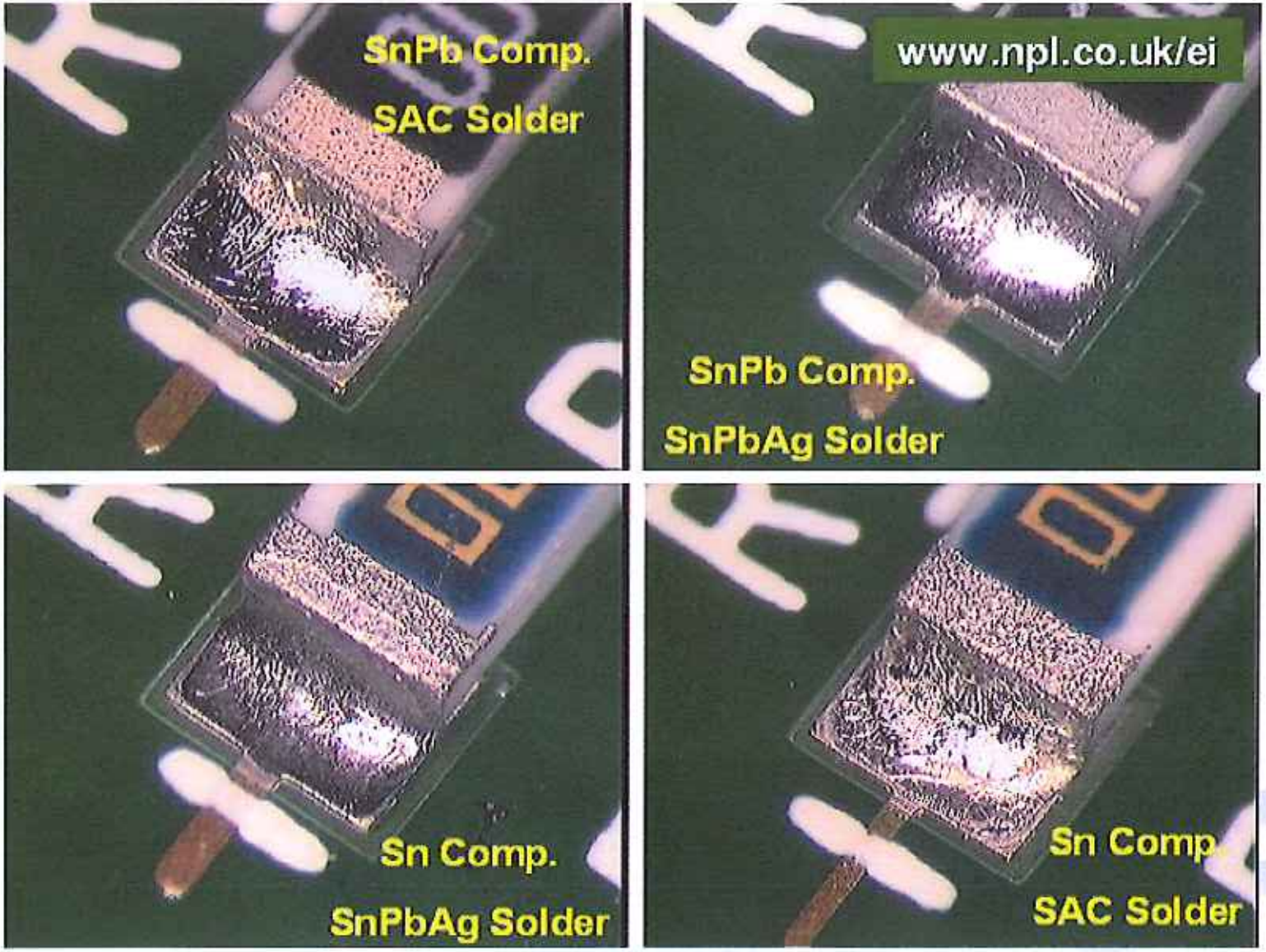
- SAC305
- Sn/Ag/Cu
- 96.5% Sn/ 3.0%Ag/ 0.5%Cu

- 96SC
- It says Tin Silver Copper
- US pat……..may be different to first reel.


SnPb Comp.
SAC Solder
www.npl.co.uk/ei
SnPb Comp.
SnPbAg Solder
Sn Comp.
SnPbAg Solder
Sn Comp
SAC Solder

Lead Free additions to J-STD-001 and IPC – A- 610

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- Lead Free--610 chapter 5 first few pages
- IPC/J-STD-001 clause 14.
- There is NO DIFFERENCE in the solder connection fillet requirements.
  - There are some differences in superficial appearance

Lead Free Solder joint requirements

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- The primary difference is related to the visual appearance of the solder.
- Acceptable lead-free and tin-lead connections may exhibit similar appearances but lead free alloys are more likely to have:
  - Surface roughness (grainy or dull).
  - Different wetting contact angles.
- All other solder fillet criteria are the same.

Solder joint Acceptable - Class 1,2,3

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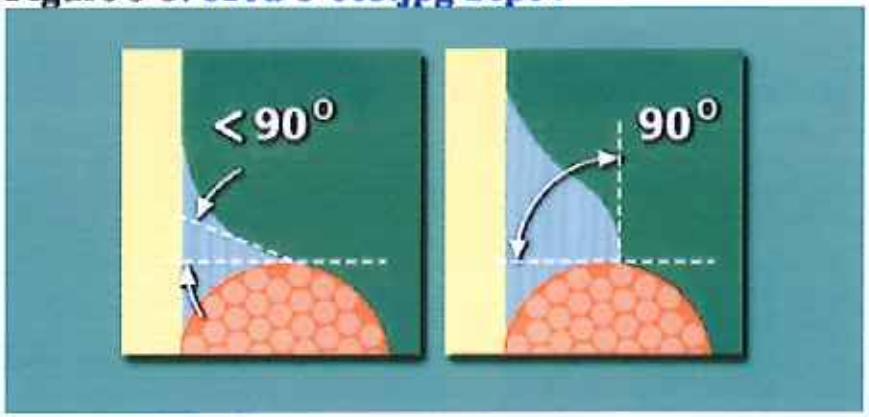
Figure 5-3. 610d-5-003.jpg Sep04



- There are materials and processes, e.g. lead free alloys and slow cooling with large mass PCBs, that may produce dull matte, gray, or grainy appearing solders that are normal for the material or process involved. These solder connections are acceptable.
- Wetting contact angle of 90° or less, except when the quantity of solder results in a contour which extends over the edge of the solderable surfaces or solder resist

Lead versus Lead Free – No Clean

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Figure 5-4. SnPb Solder; No Clean Process

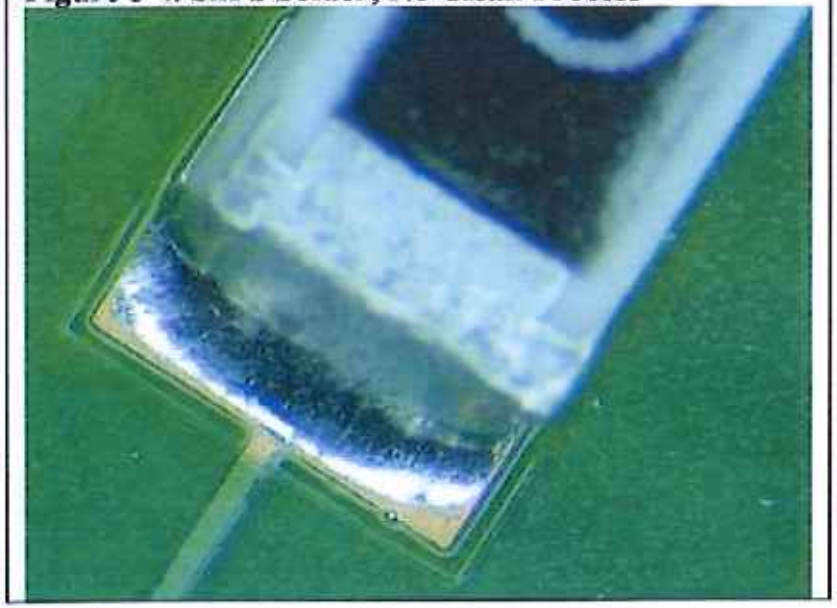
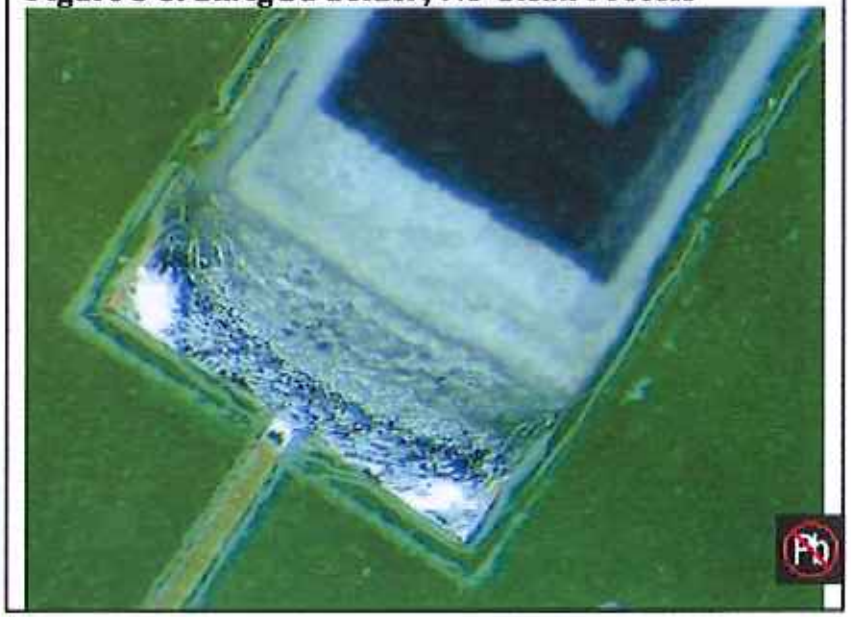


Figure 5-5. SnAgCu Solder; No Clean Process



Lead vs. lead free – Water Soluble Flux

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Figure 5-6. SnPb Solder, Water Soluble Flux

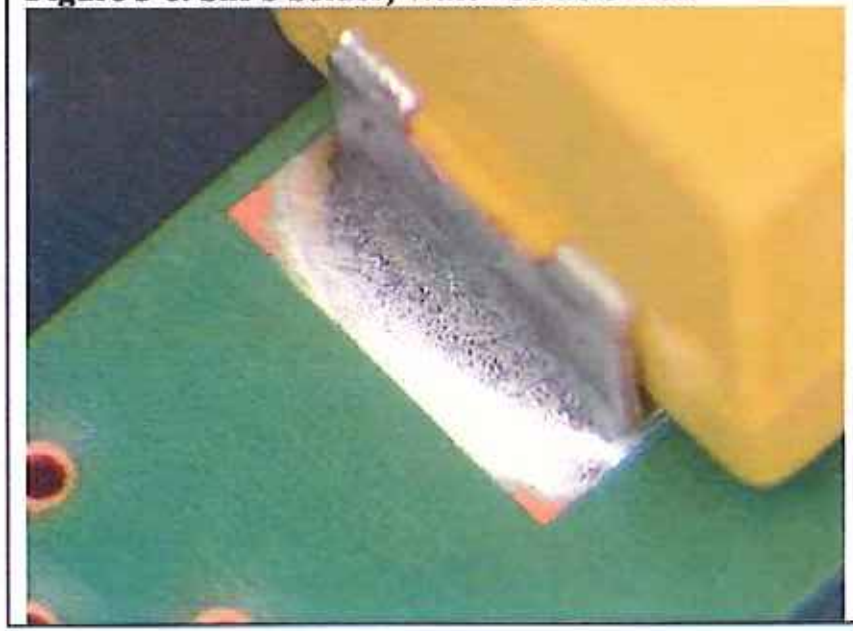

Figure 5-7. SnAgCu Solder, Water Soluble Flux

Flat pack Water Soluble flux

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Figure 5-8. SnPb Solder, Water Soluble Flux

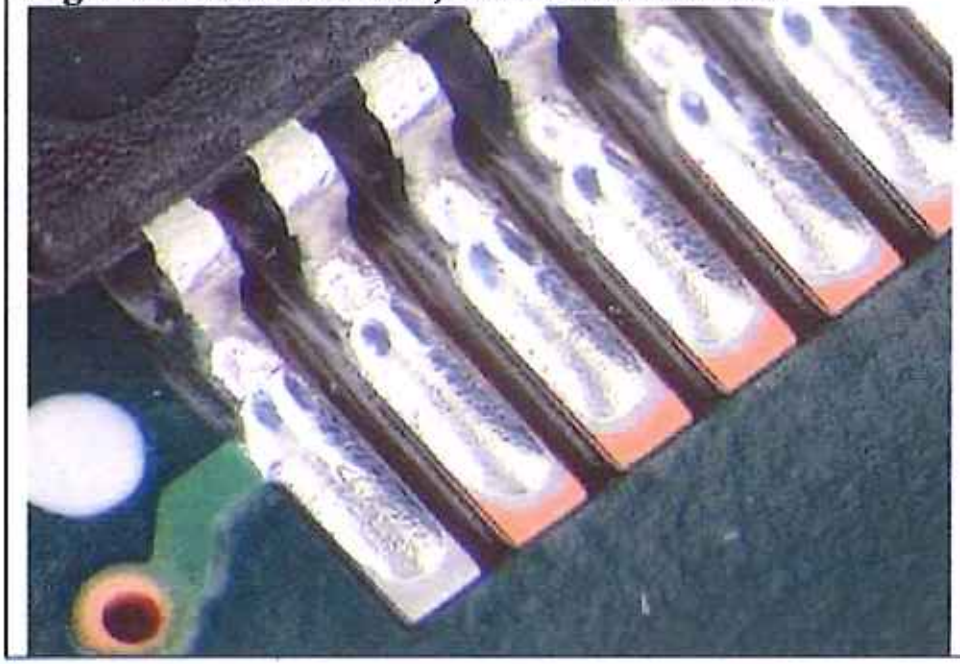
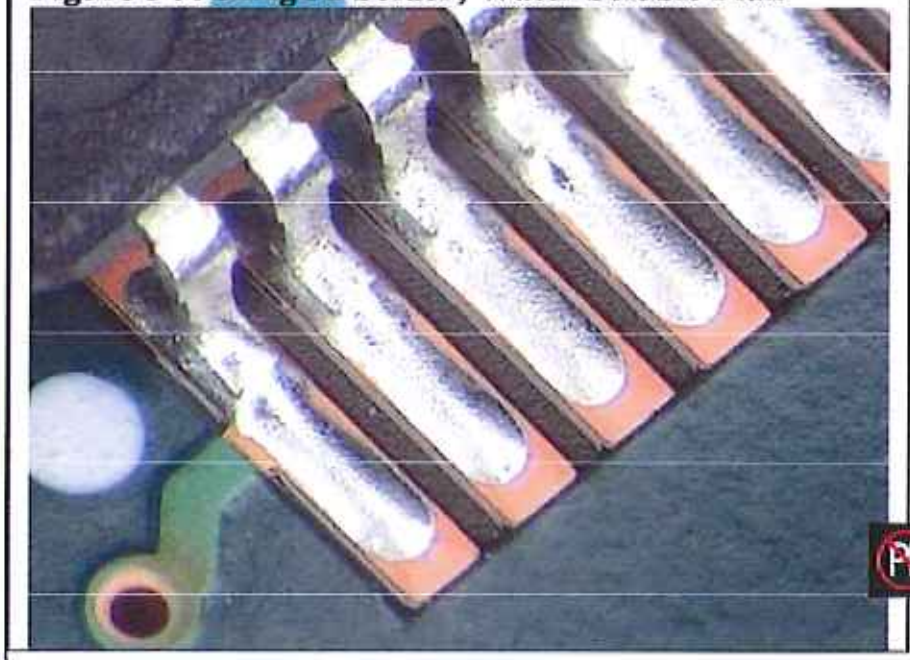


Figure 5-9. SnAgCu Solder; Water Soluble Flux



BGA No Clean

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Figure 5-14. SnPb Solder; No Clean Process

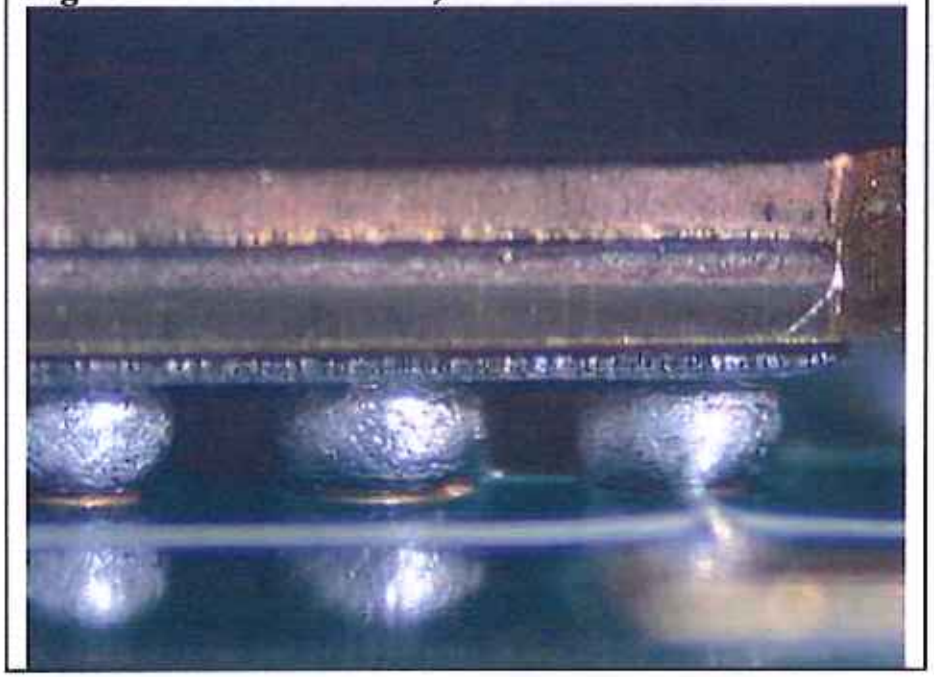
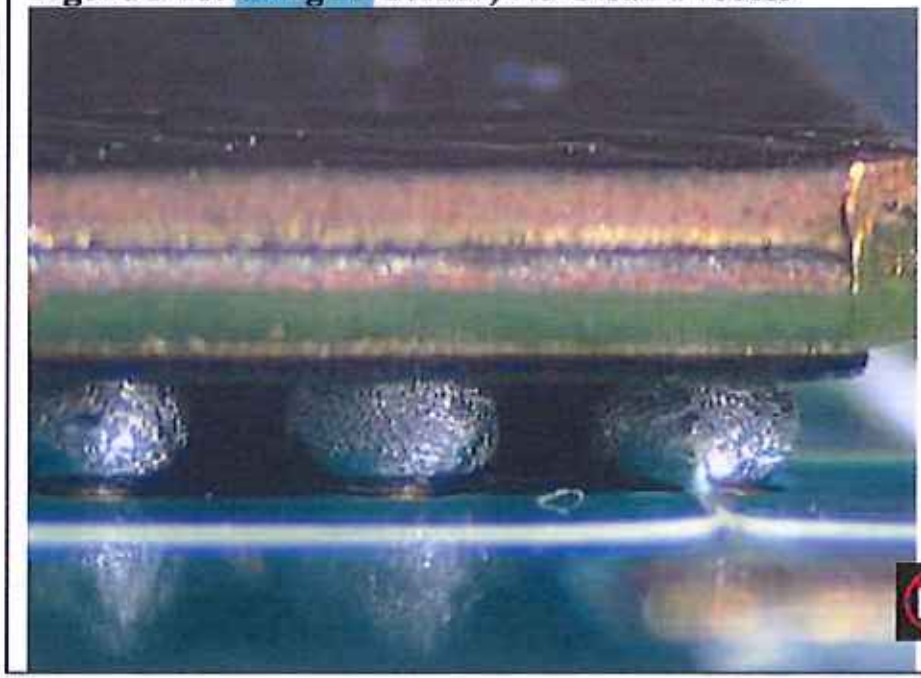


Figure 5-15. SnAgCu Solder; No Clean Process



Special Lead free requirements

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Figure 5-64. 610d-5-048.jpg

Figure 5-65. Crack2 THLA.jpg

5.2.10 Soldering Anomalies – Lead Free

Acceptable lead free connections may exhibit:

- Fillet lifting - separation of the bottom of the solder and the top of the land
- Shrink holes, fissures or hot tearing

BGA Voiding

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- Design induced voids, e.g., microvia in land, are excluded from this criteria. (manufacturer/user discussion)
- Manufacturers may use test or analysis to develop alternate acceptance criteria for voiding that consider the end-use environment.

Acceptable - Class 1,2,3

• 25% or less voiding of the ball x-ray image area.

Defect - Class 1,2,3

• More than 25% voiding in the ball x-ray image area.

BGA Voiding Controversy

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- Controversy: Why 25% and not 35%?
- IPC-A-610 committee was provided data that established acceptability of 25% figure. Did not have data regarding higher levels even though these might be okay.

Lead-Free Surface Testing

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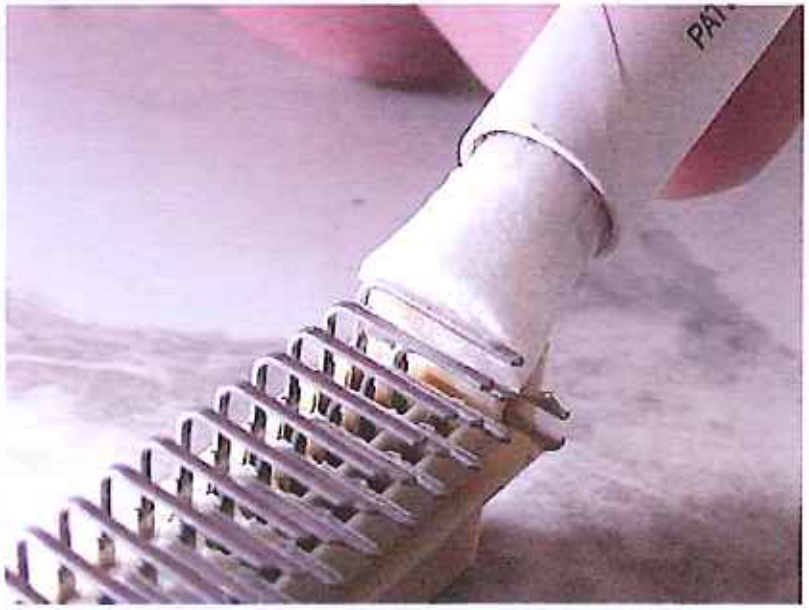

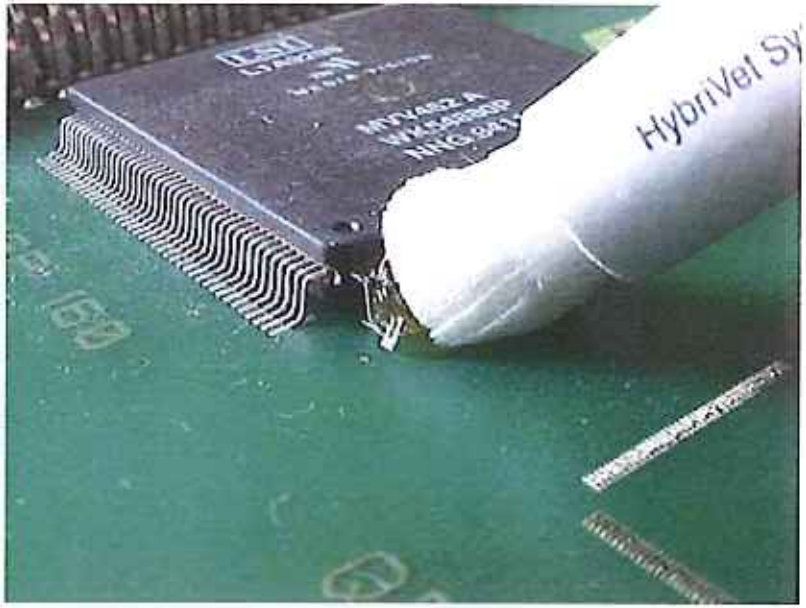

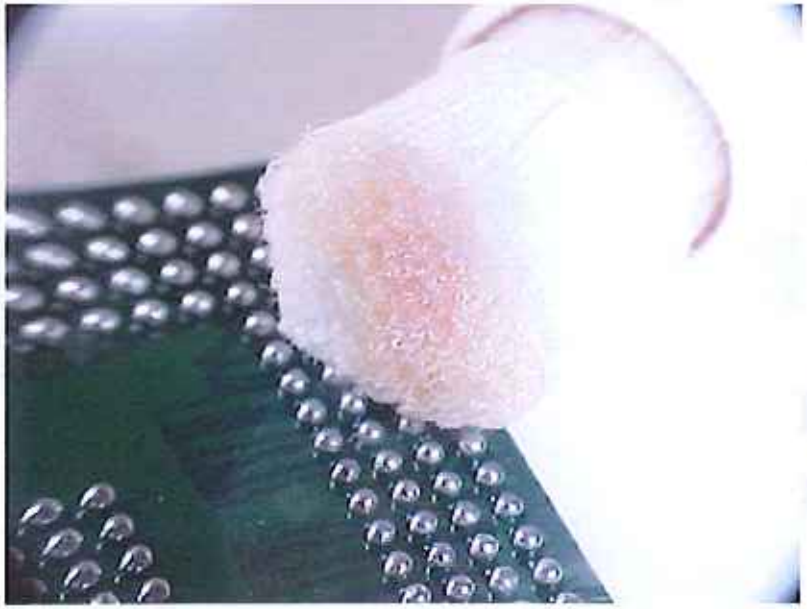

NPL Reported

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- 4 test kits tested
- 3 failed to detect lead in a 40% lead solder termination
- The successful kit failed to detect lead at 15% in further tests.

Can you see the difference?

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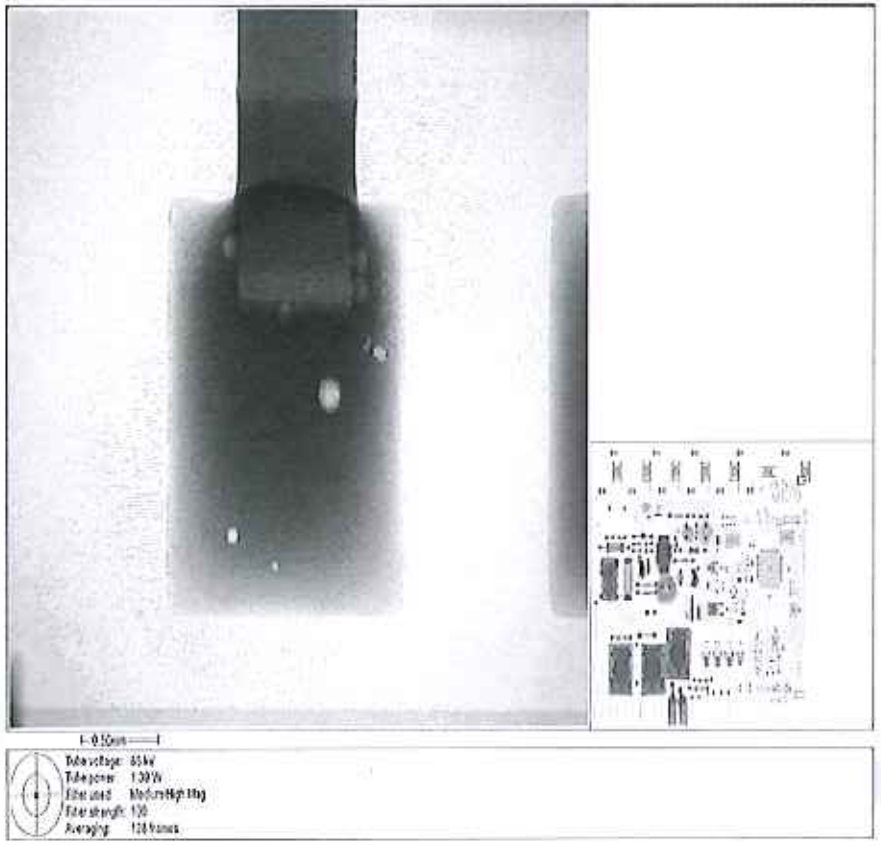

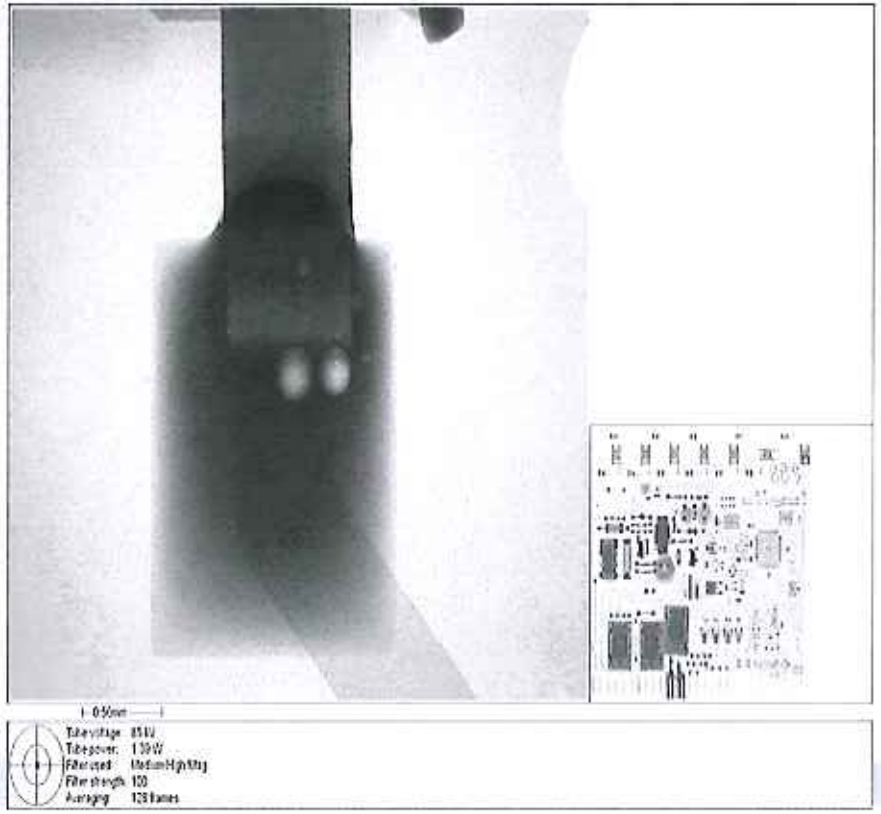

Now you can!!

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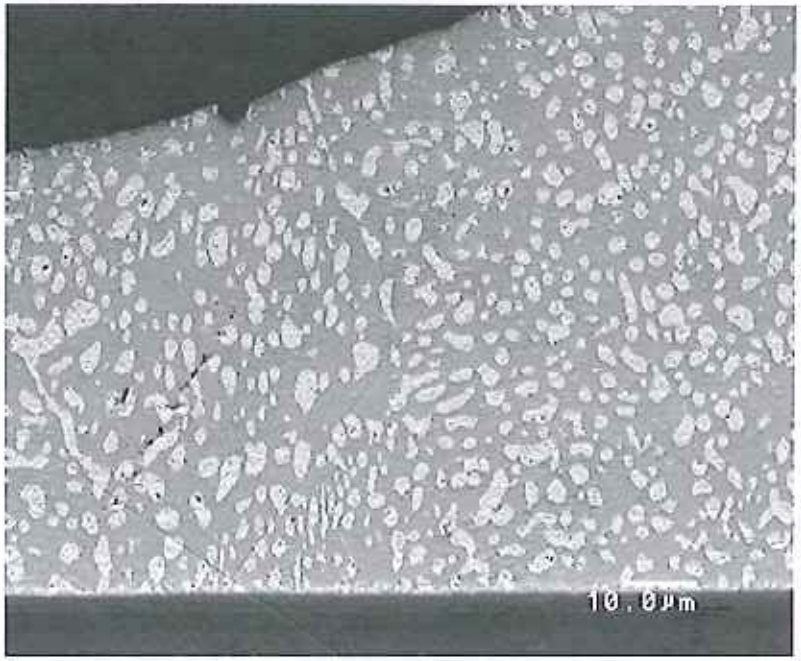

Lead-free Solder

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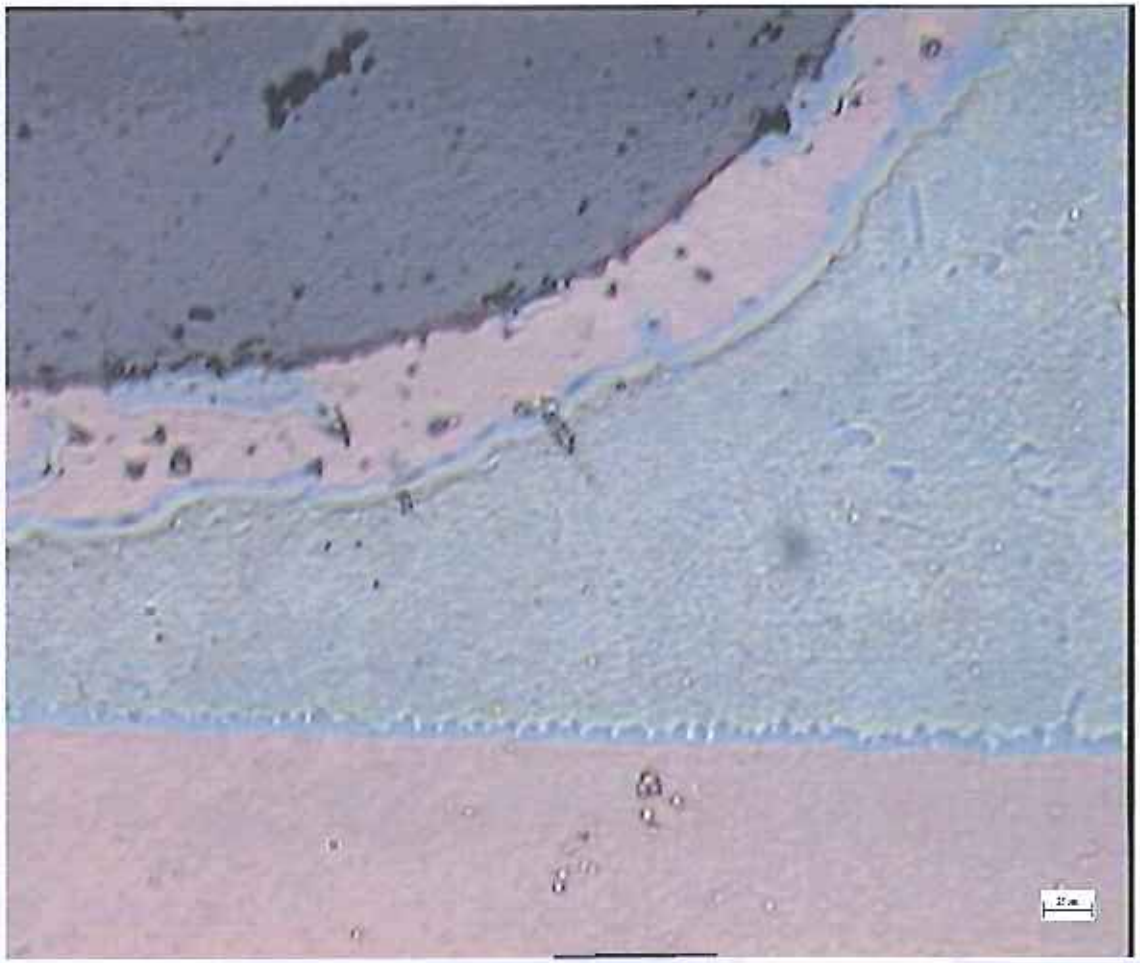
- Still have IML
- Voiding still possible
- Wetting similar



X-ray inspection

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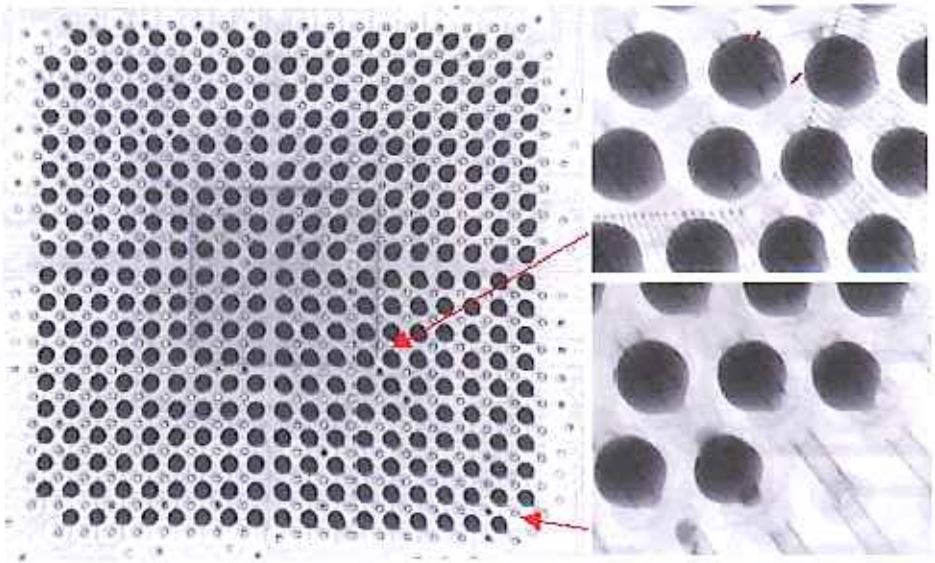
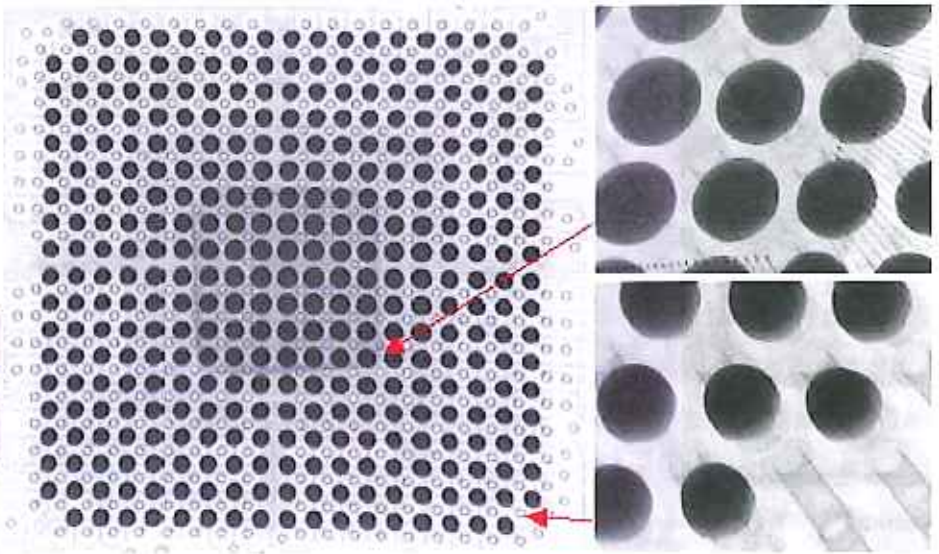


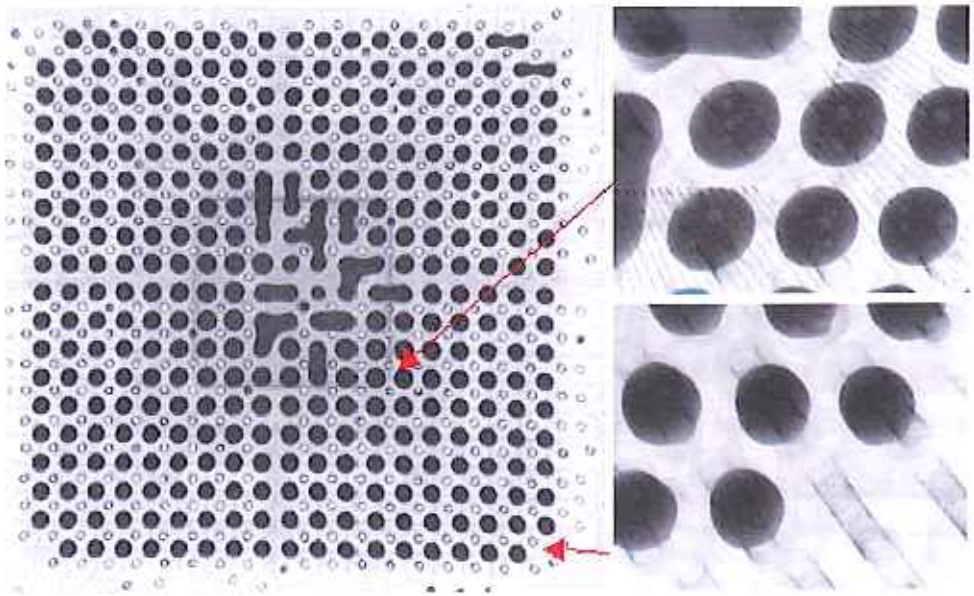
Popcorning in BGAs

From IPC7095A

PASSED Section 7.5.7 – "…popcorning and warpage are generally caused by improper handling of the BGA component prior to reflow. Popcorning causes the BGA package to expand below the die; resulting in an increase in size (and possibly bridging) of the solder balls in the center of the package as they are squished between the package and the board."



FAILED



Moisture Sensitivity Levels

Level Indicator	*Floor Time*	*Floor Condition*
1	Unlimited	≤ 30oC/85%RH
2	1 year	≤ 30oC/85%RH
2a	4 weeks	≤ 30oC/85%RH
3	168 hours	≤ 30oC/85%RH
4	72 hours	≤ 30oC/85%RH
5	38 hours	≤ 30oC/85%RH
5a	24 hours	≤ 30oC/85%RH
6	Time on label	≤ 30oC/85%RH

Outlined in IPC/JEDEC J-STD-020C

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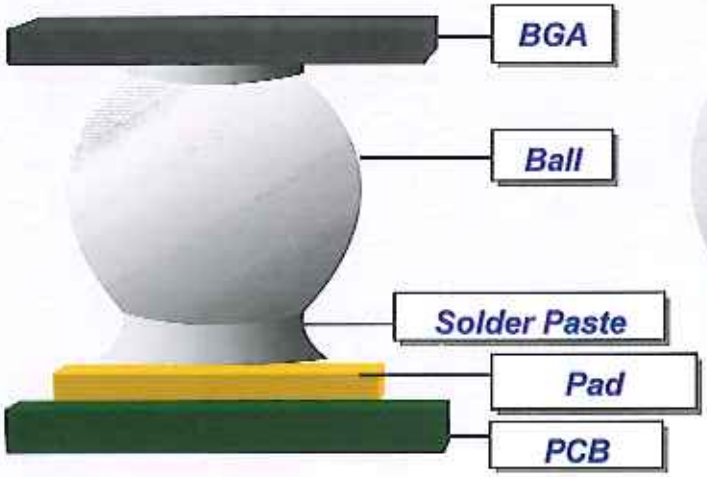
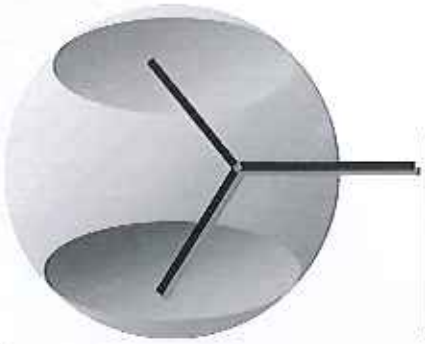
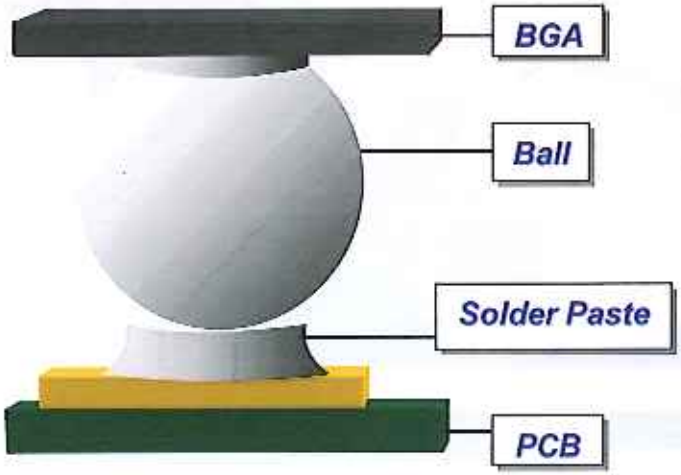
BGA Opens Using Digital X-ray Inspection

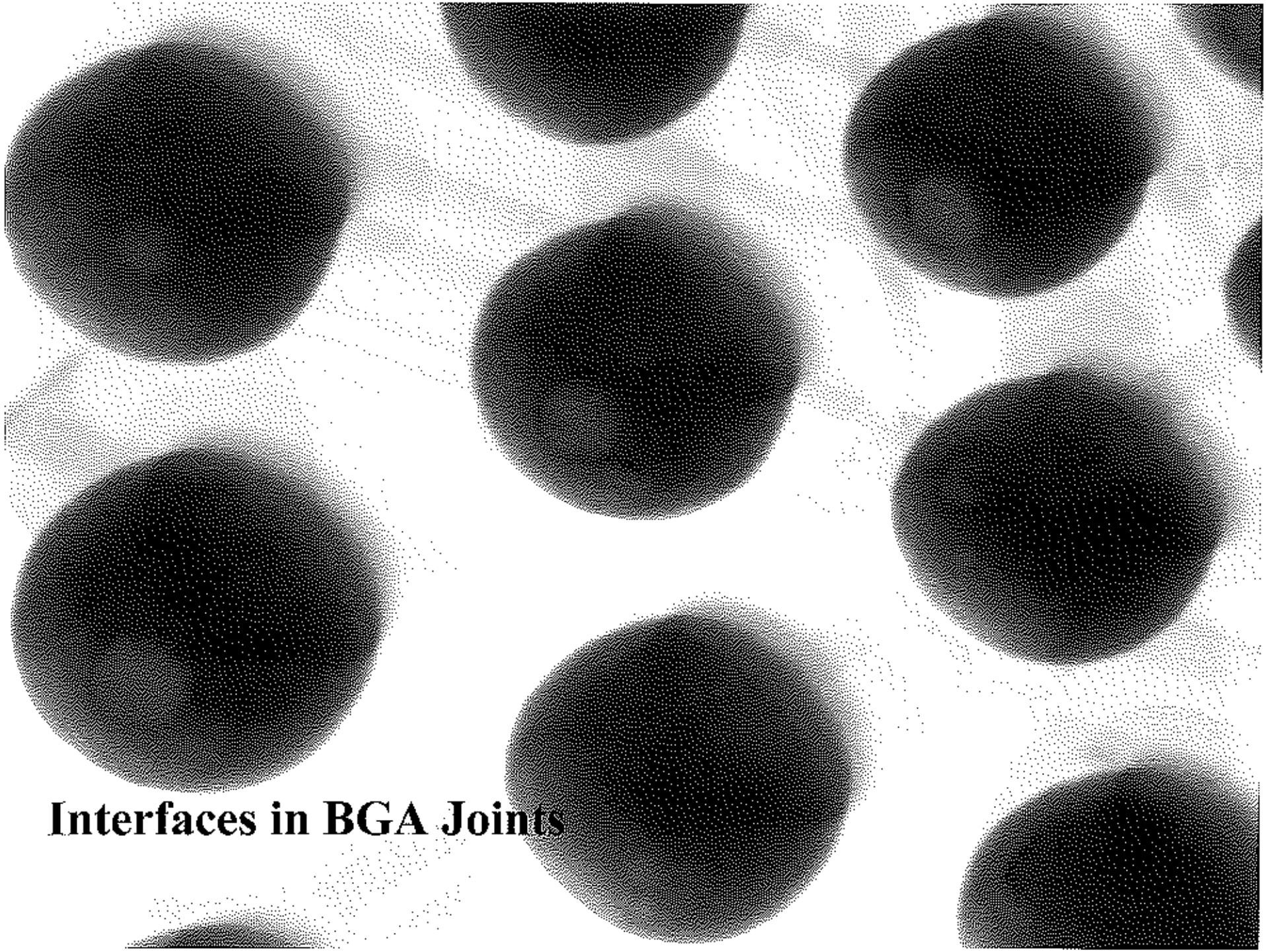




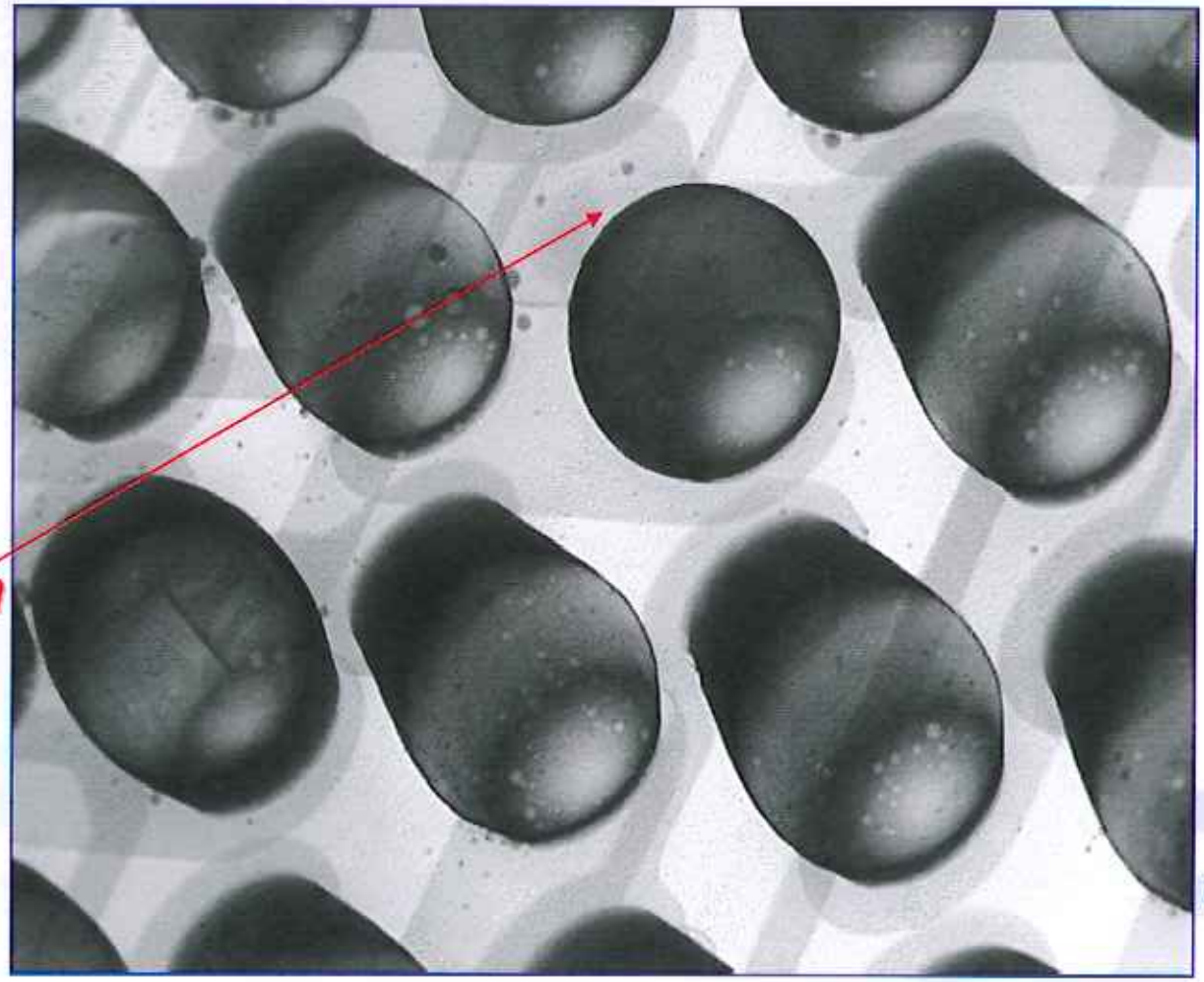
2 ellipses on the x-ray image show BGA connection are OK

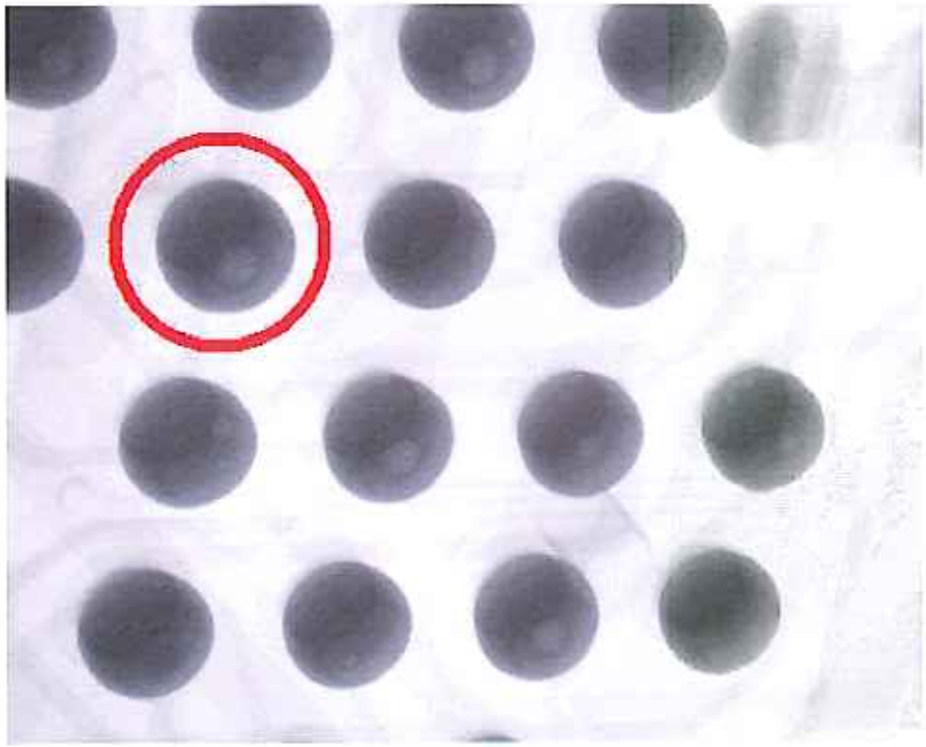


Missing ellipse indicates open joint

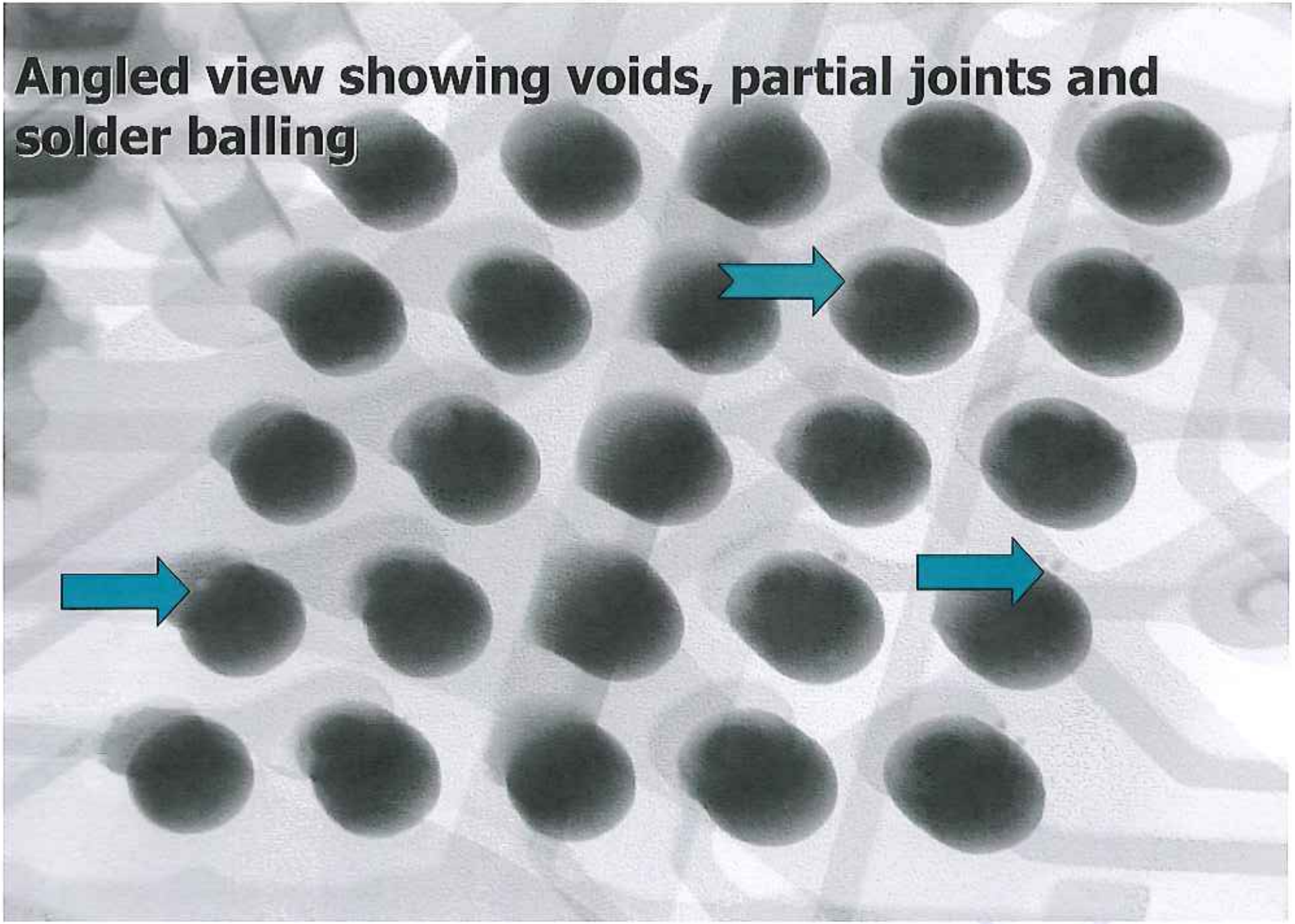

Interfaces in BGA Joints

Lead-free CSP Image





- Missing ellipse can indicate open joints
- Very subtle greyscale differences
- Location of void with respect to interface is very clear


Angled view showing voids, partial joints and solder balling

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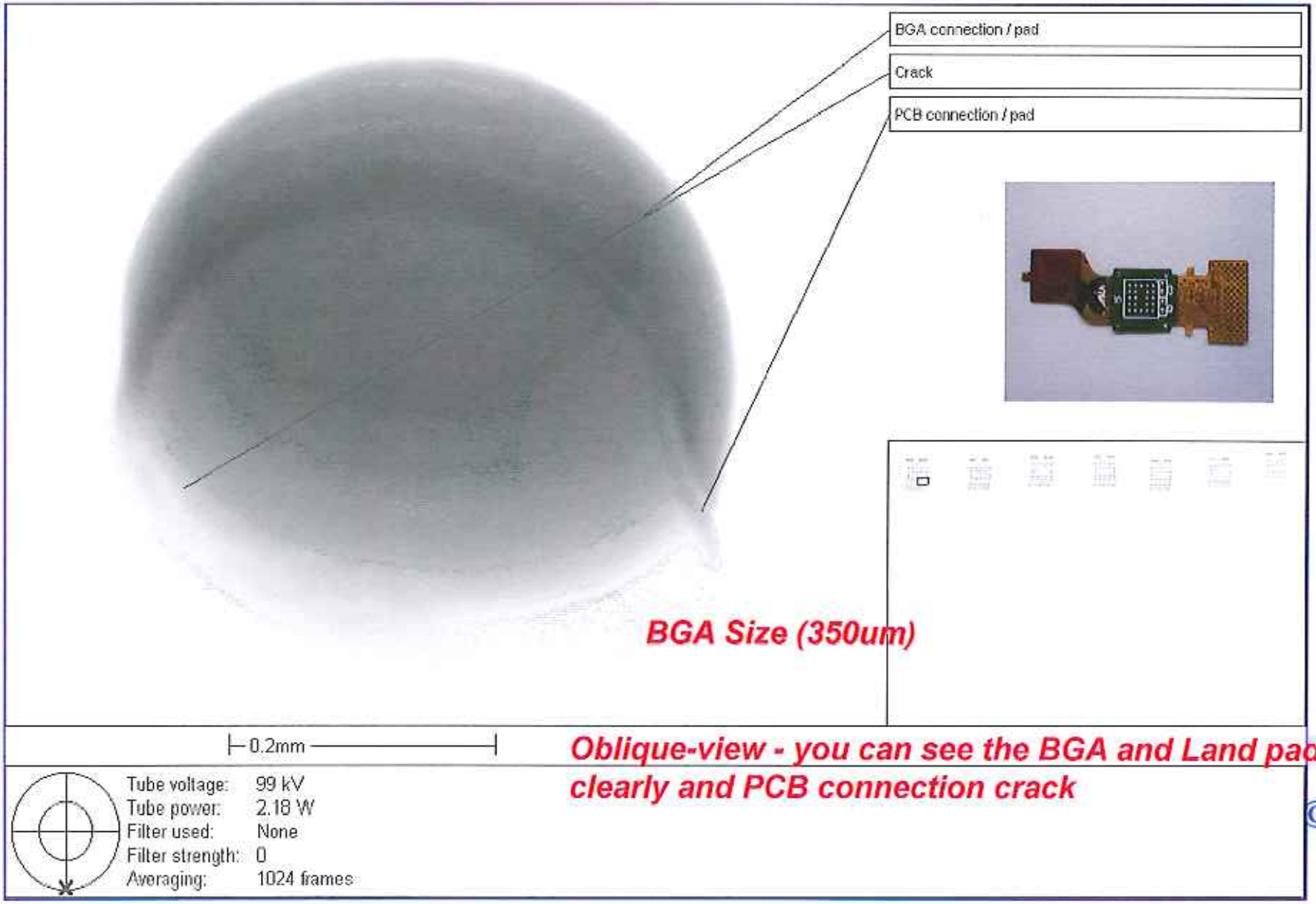
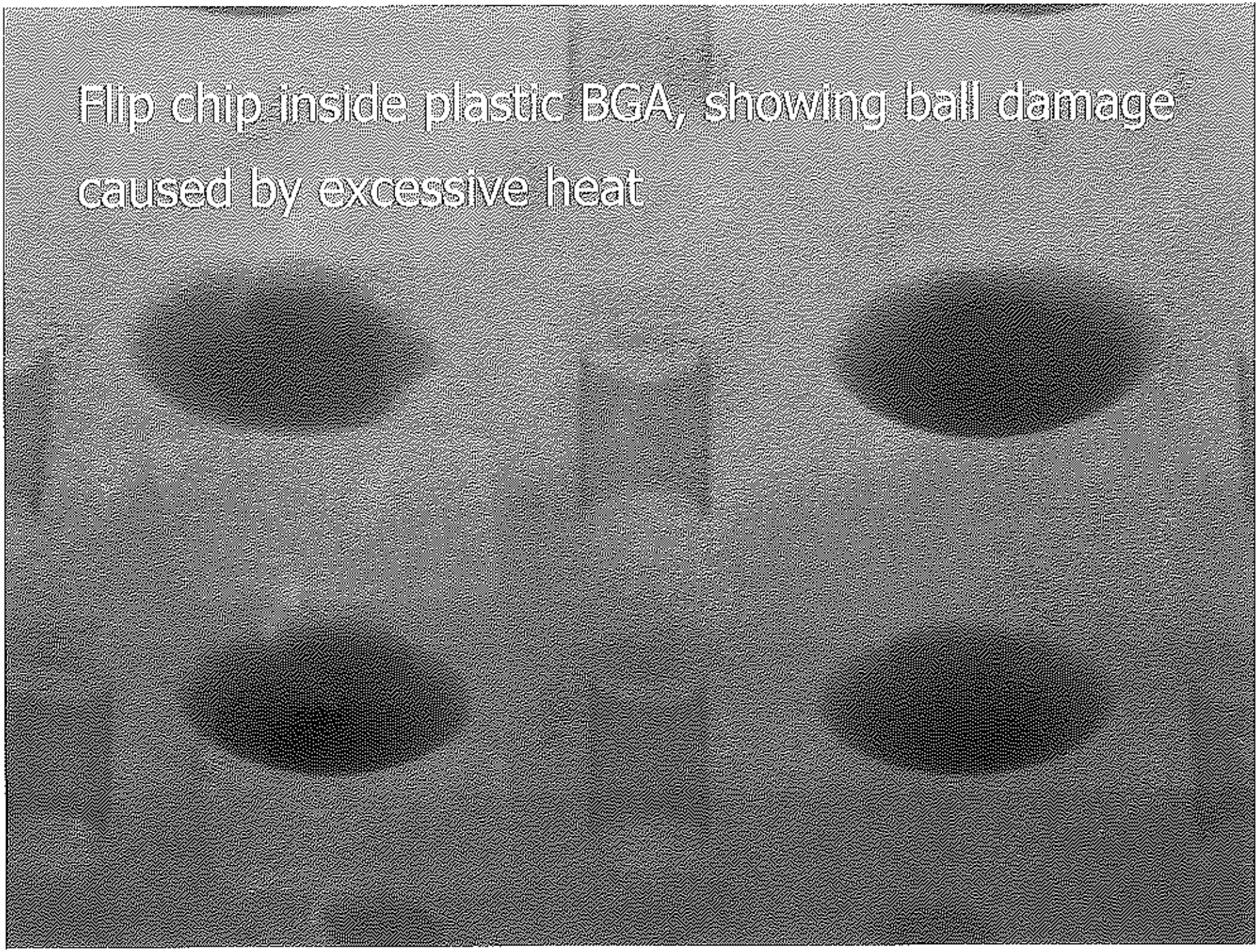
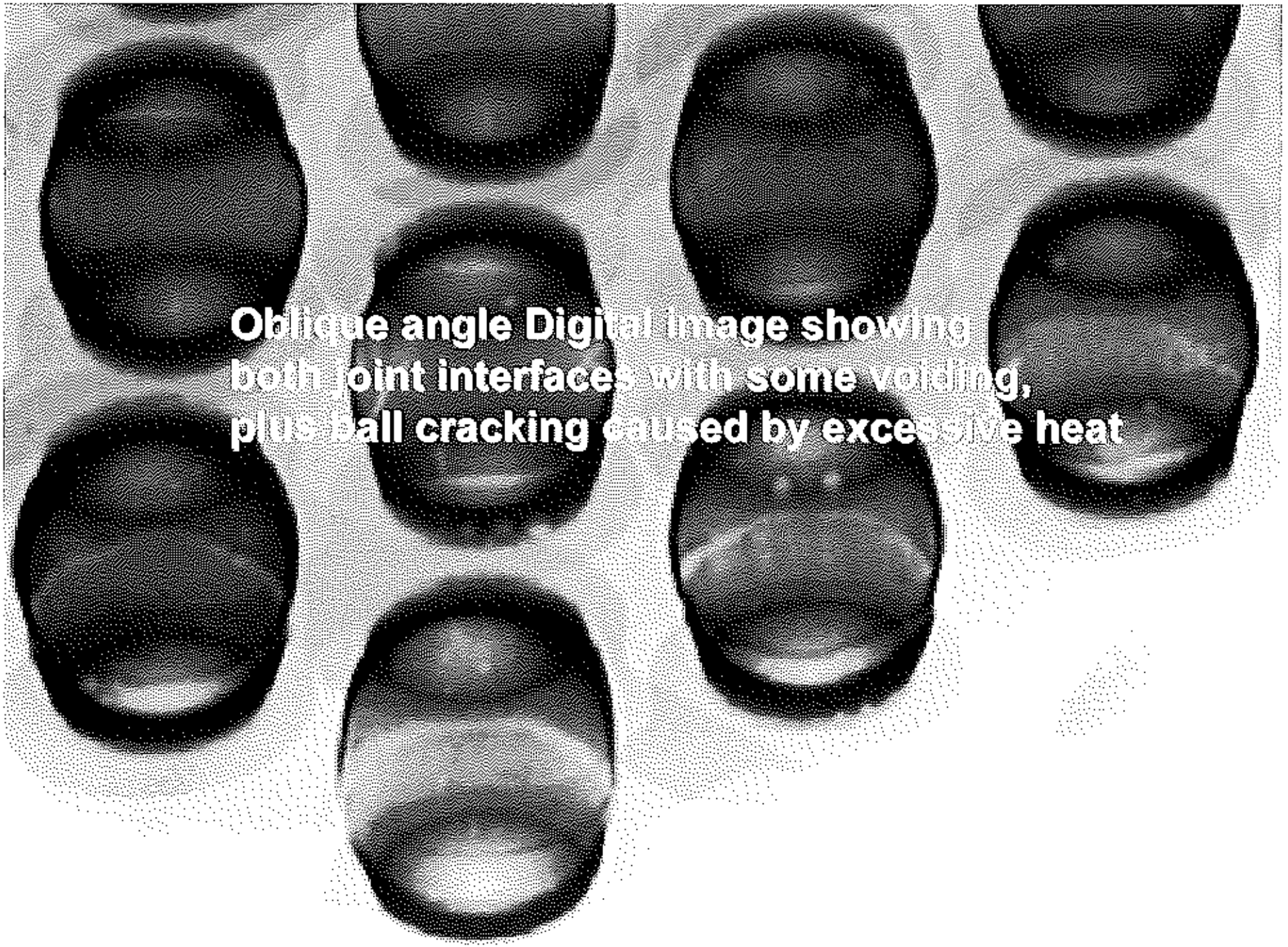
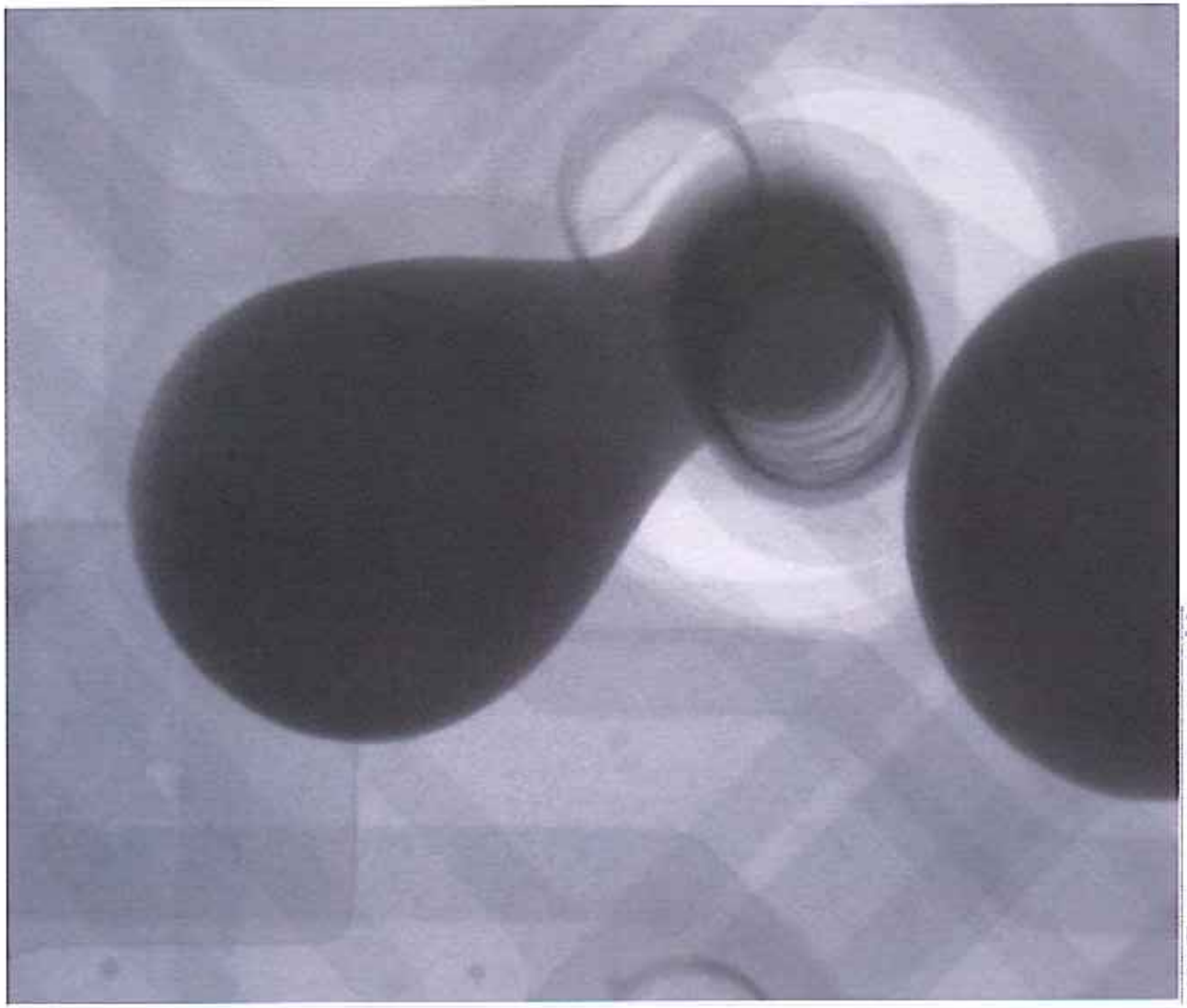


Oblique-view - you can see the BGA and Land pad clearly and PCB connection crack


Flip chip inside plastic BGA, showing ball damage
caused by excessive heat



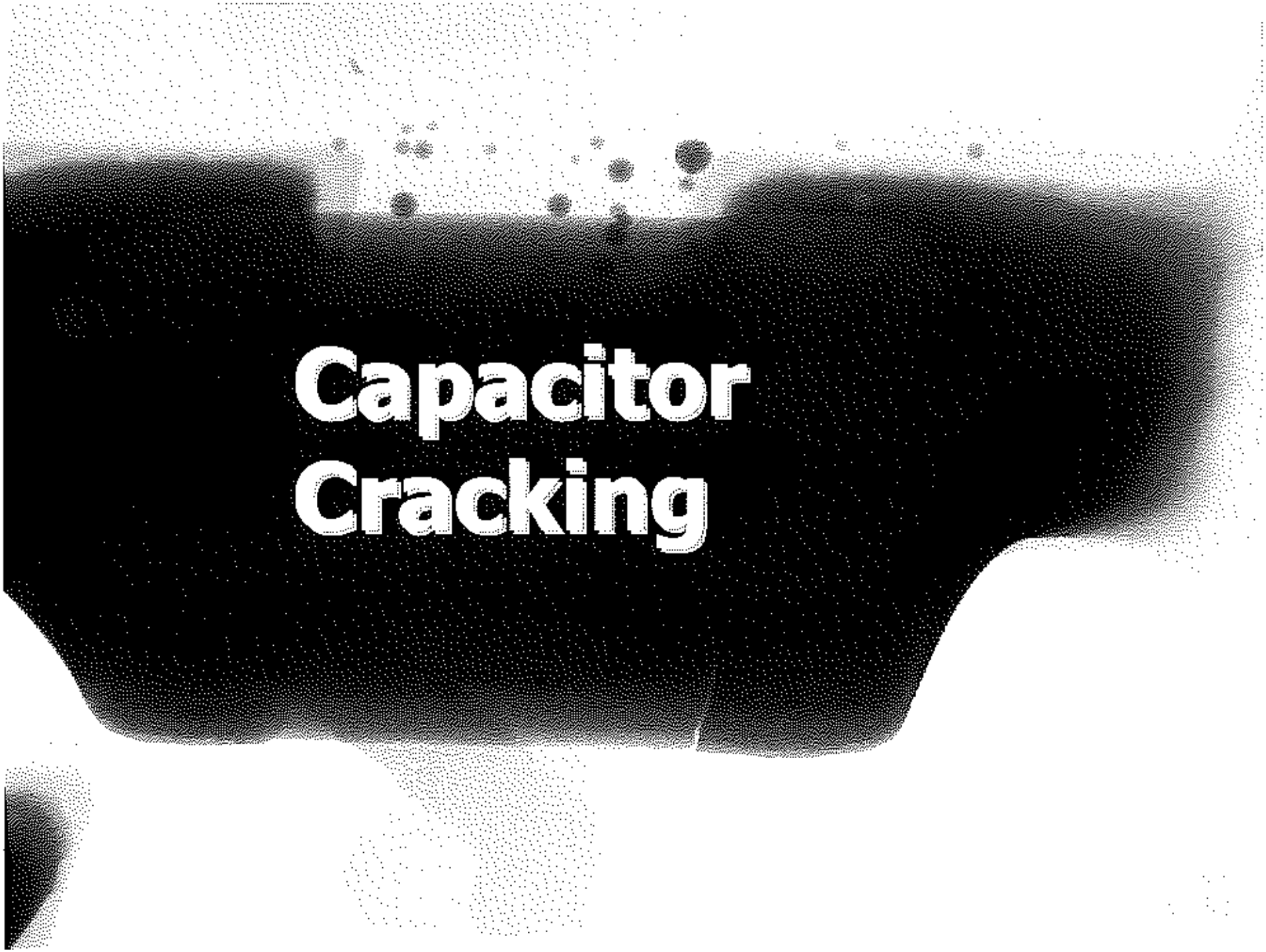
Oblique angle Digital image showing
both joint interfaces with some voiding,
plus ball cracking caused by excessive heat

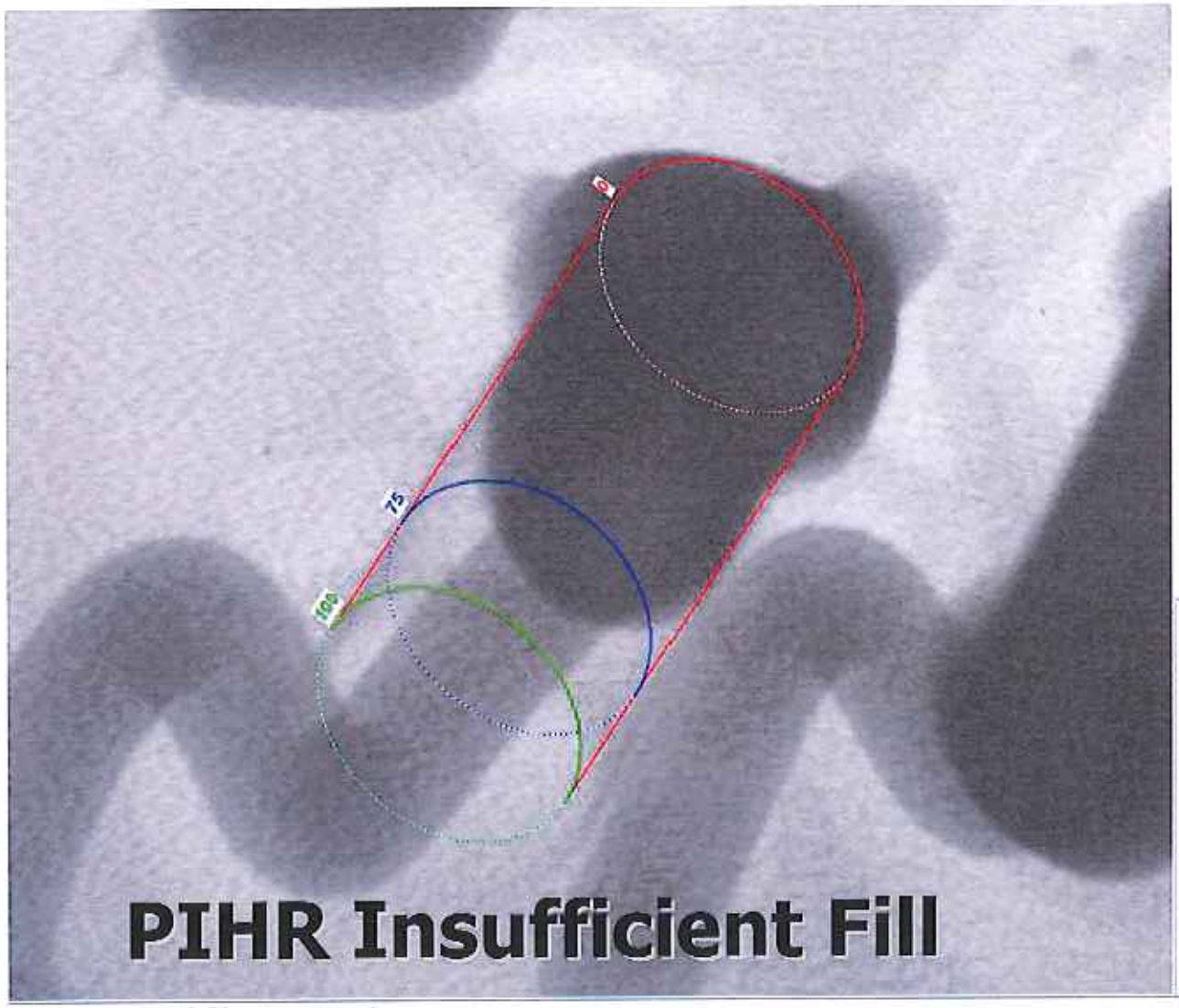


BGA ball escaping down a via

— 0.25mm —

Tube voltage:	95 kV
Tube power:	1.19 W
Filter used:	None
Filter strength:	0
Averaging:	128 frames


Capacitor
Cracking



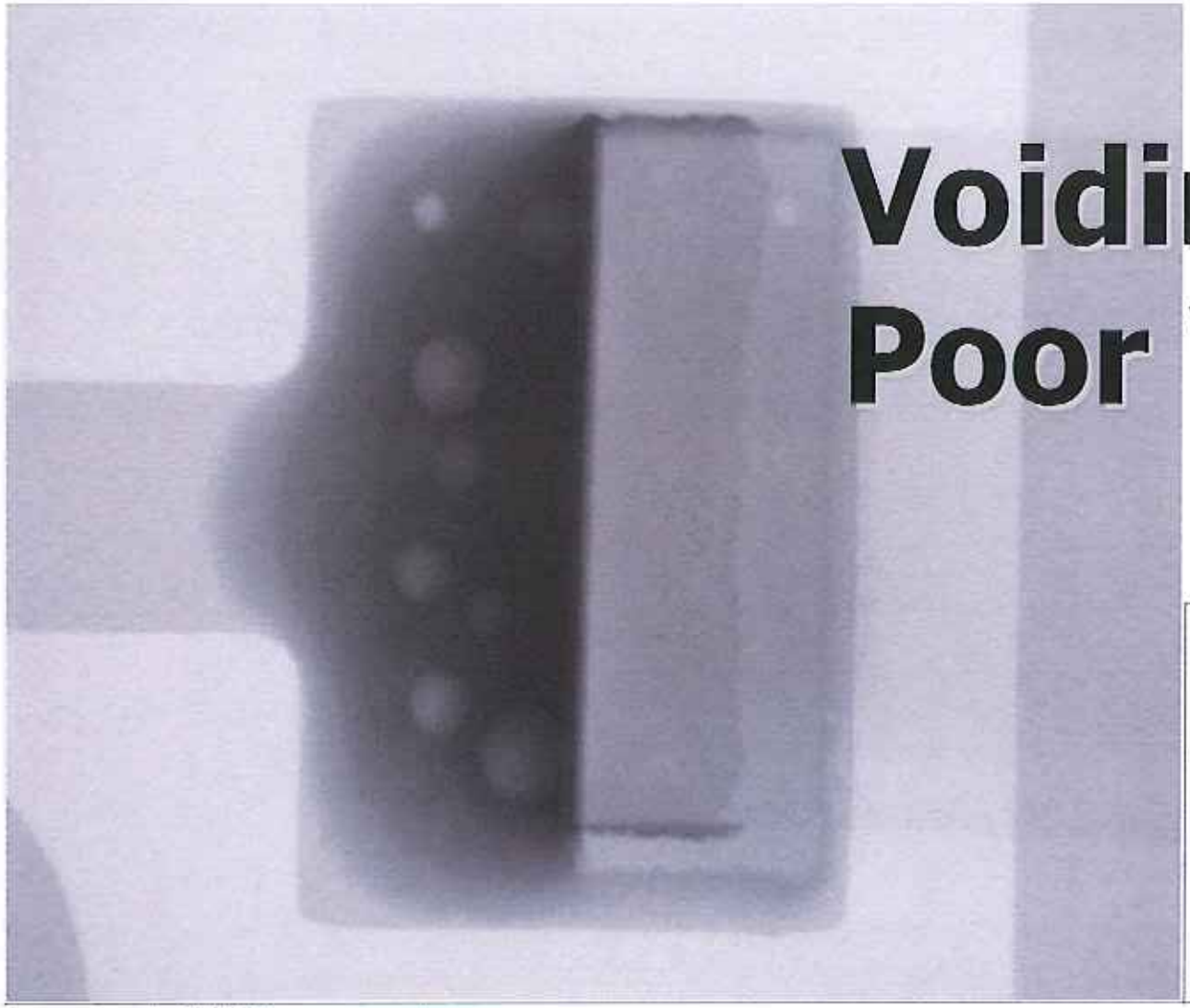
PIHR Insufficient Fill

dage

0.50mm

Tube voltage:	90 kV
Tube power:	0.50 W
Filter used:	None
Filter strength:	0
Averaging:	32 frames

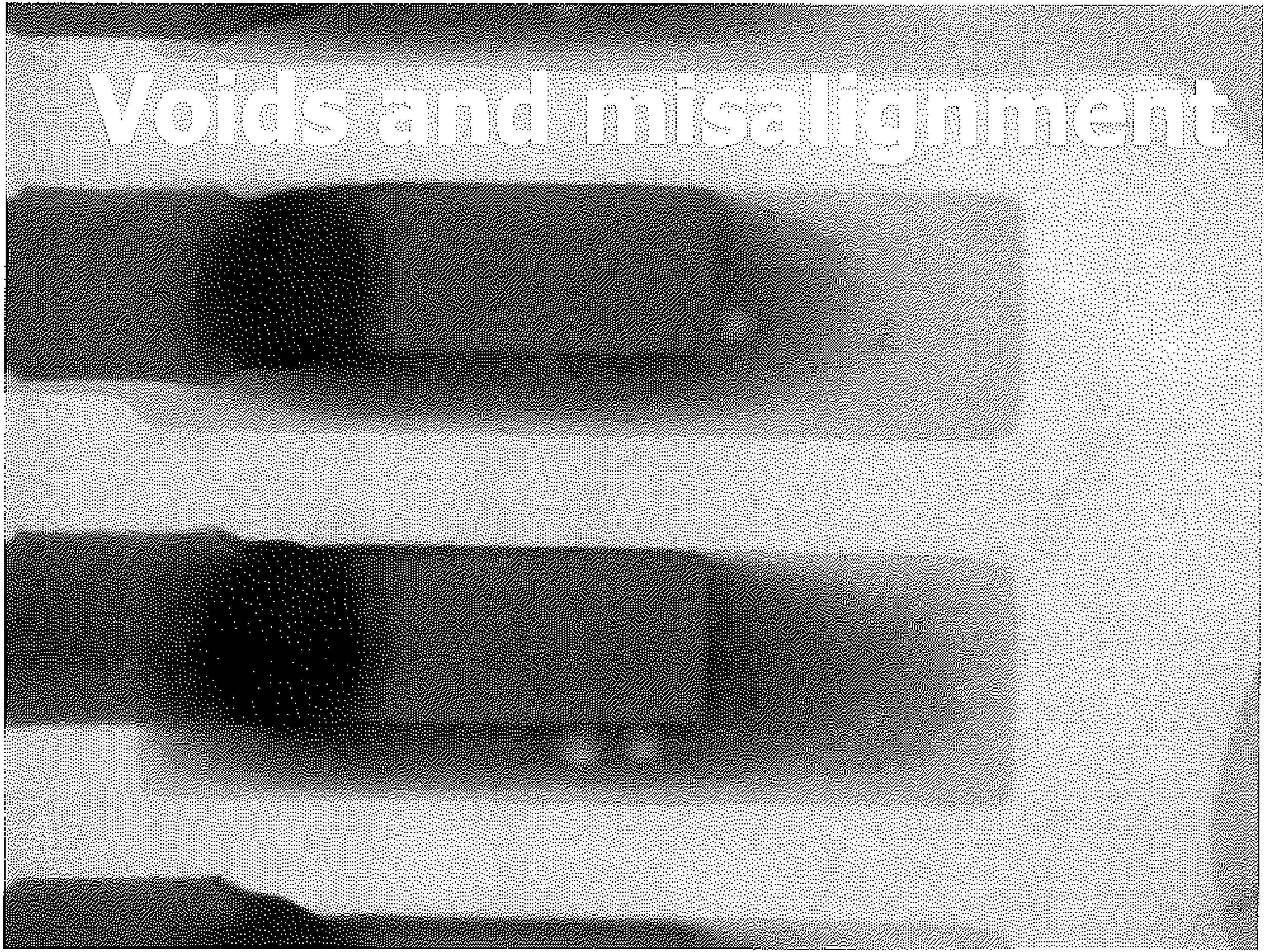
Voiding & Poor Wetting

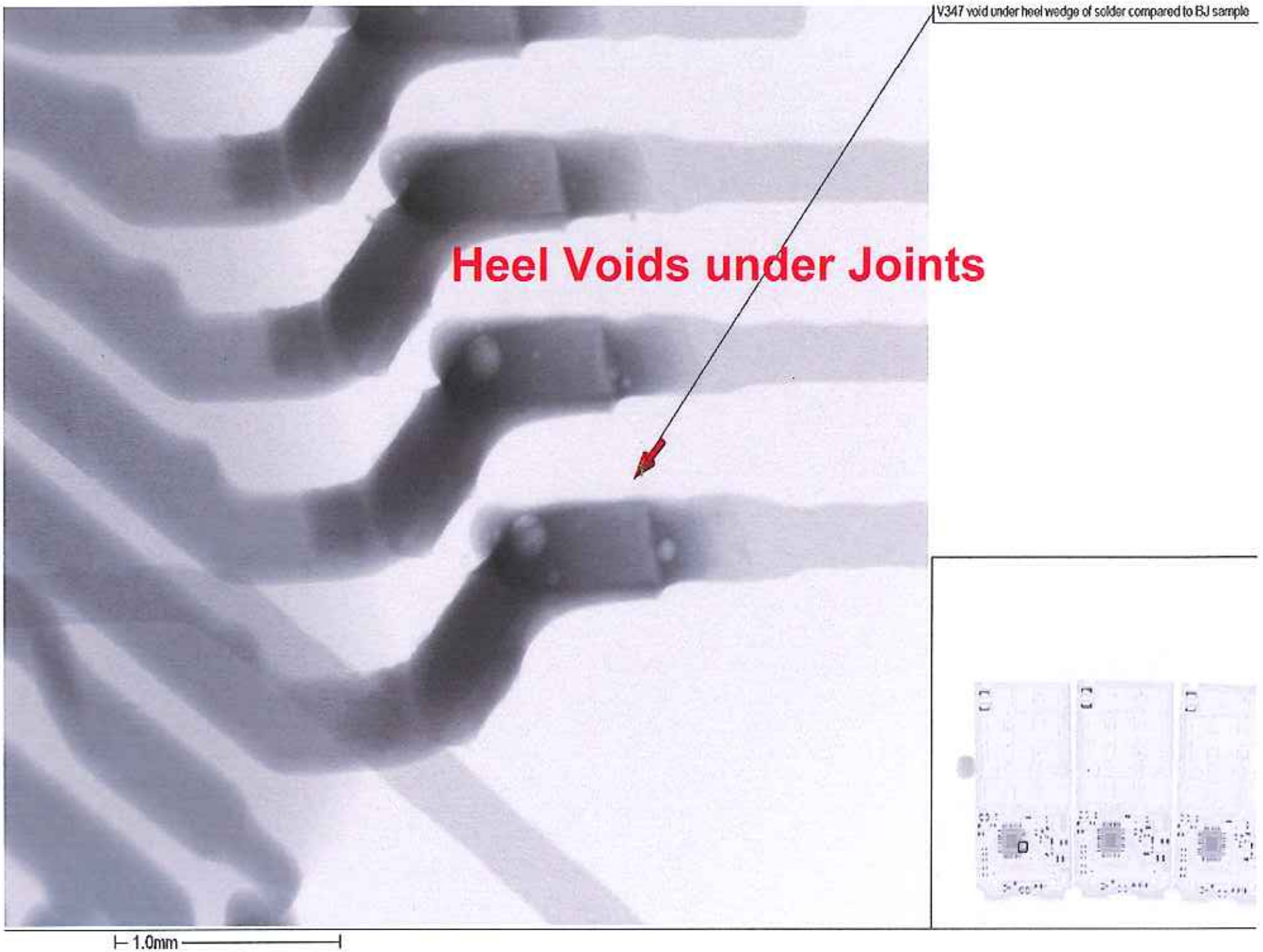


dage

0.50mm

Tube voltage:	80 kV
Tube power:	1.49 W
Filter used:	None
Filter strength:	0
Averaging:	128 frames


Voids and misalignment


V347 void under heel wedge of solder compared to BJ sample
Heel Voids under Joints
1.0mm

Outgoing QA Inspection

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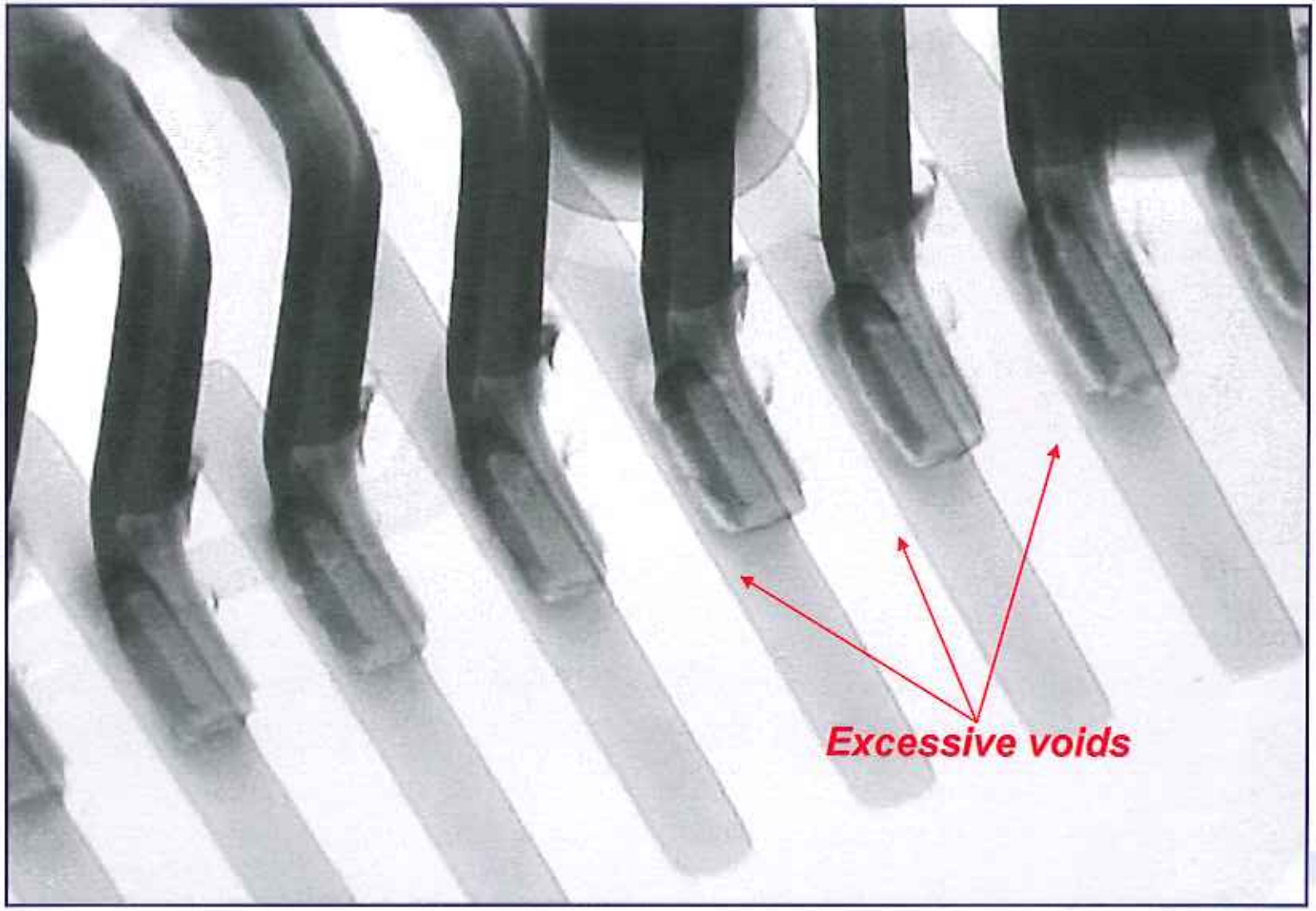
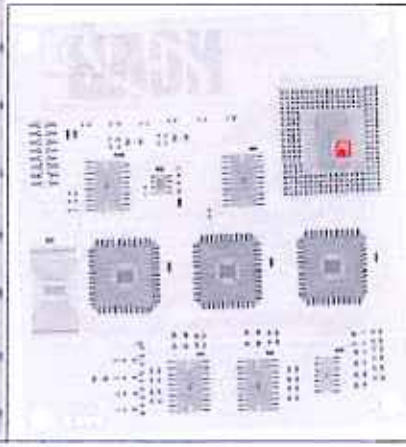
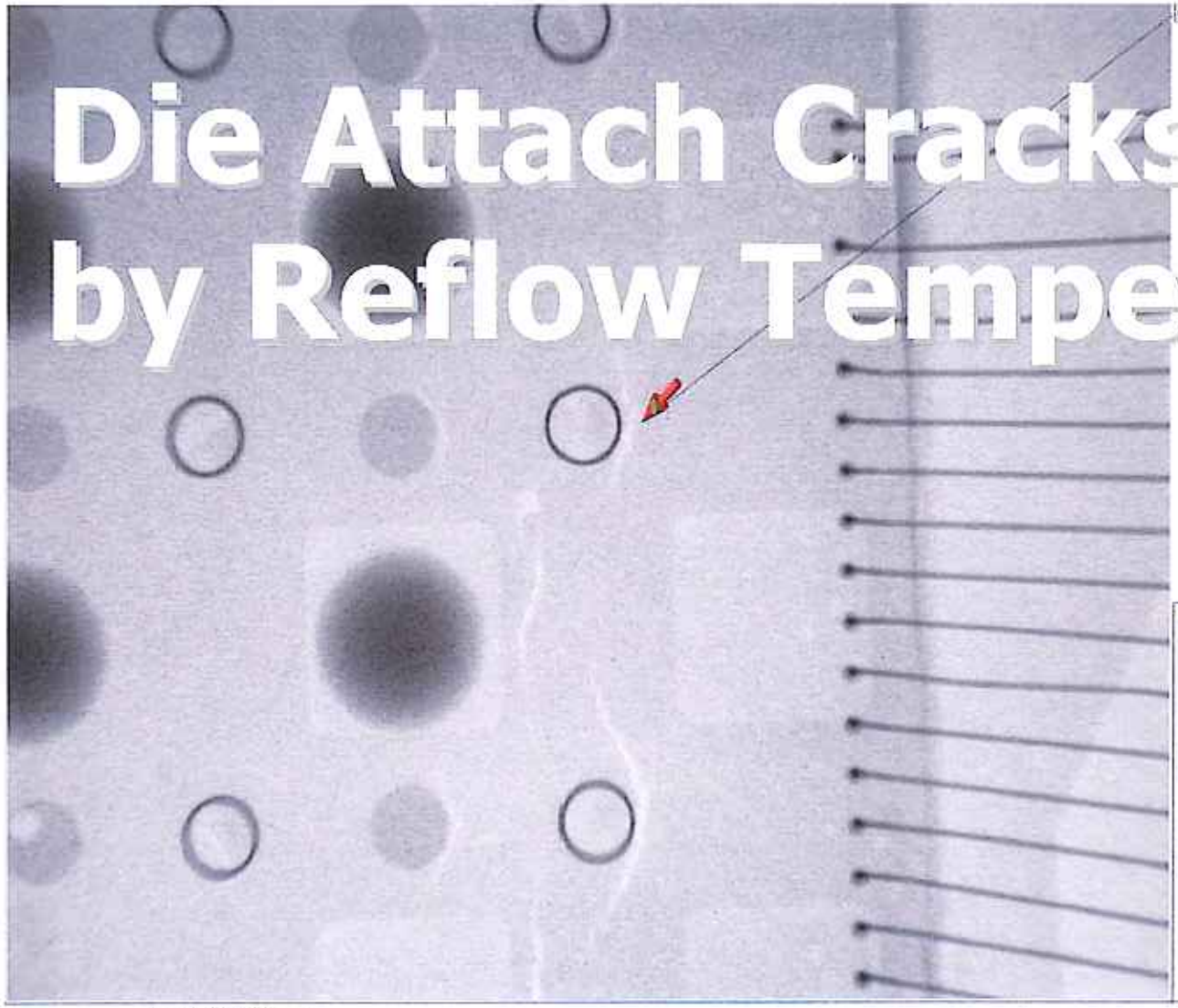


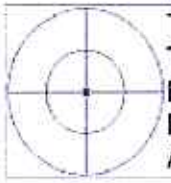
ICT / AOI are not able to spot this defect but X-ray can

Die Attach Cracks caused by Reflow Temperature





⊢ 0.50mm ⊣



Tube voltage:	114 kV
Tube power:	1.40 W
Filter used:	Edge fast 1
Filter strength:	33
Averaging:	128 frames

What is being restricted by RoHS?

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- Lead
- Mercury
- Cadmium
- Chromium (vi)
- PBB (Polybrominated biphenyls)
- PBDE (Polybrominated diphenyl ethers)

- All restricted to 1000ppm, except Cd which is 100ppm

- Risks to health include damage to liver and central nervous system, birth defects, carcinogens & endocrine distruption.

RoHS: Impurity Limits

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- Maximum Concentration Values in weight percent
  - 0.1% for Pb, Hg, hex. Cr
  - 0.01% for Cd
  - 0.1% for PBB and PBDE flame retardants
- Concentration is per homogeneous material
- 'Homogeneous material means a material that cannot be mechanically disjointed into different materials'

Example of Materials.....

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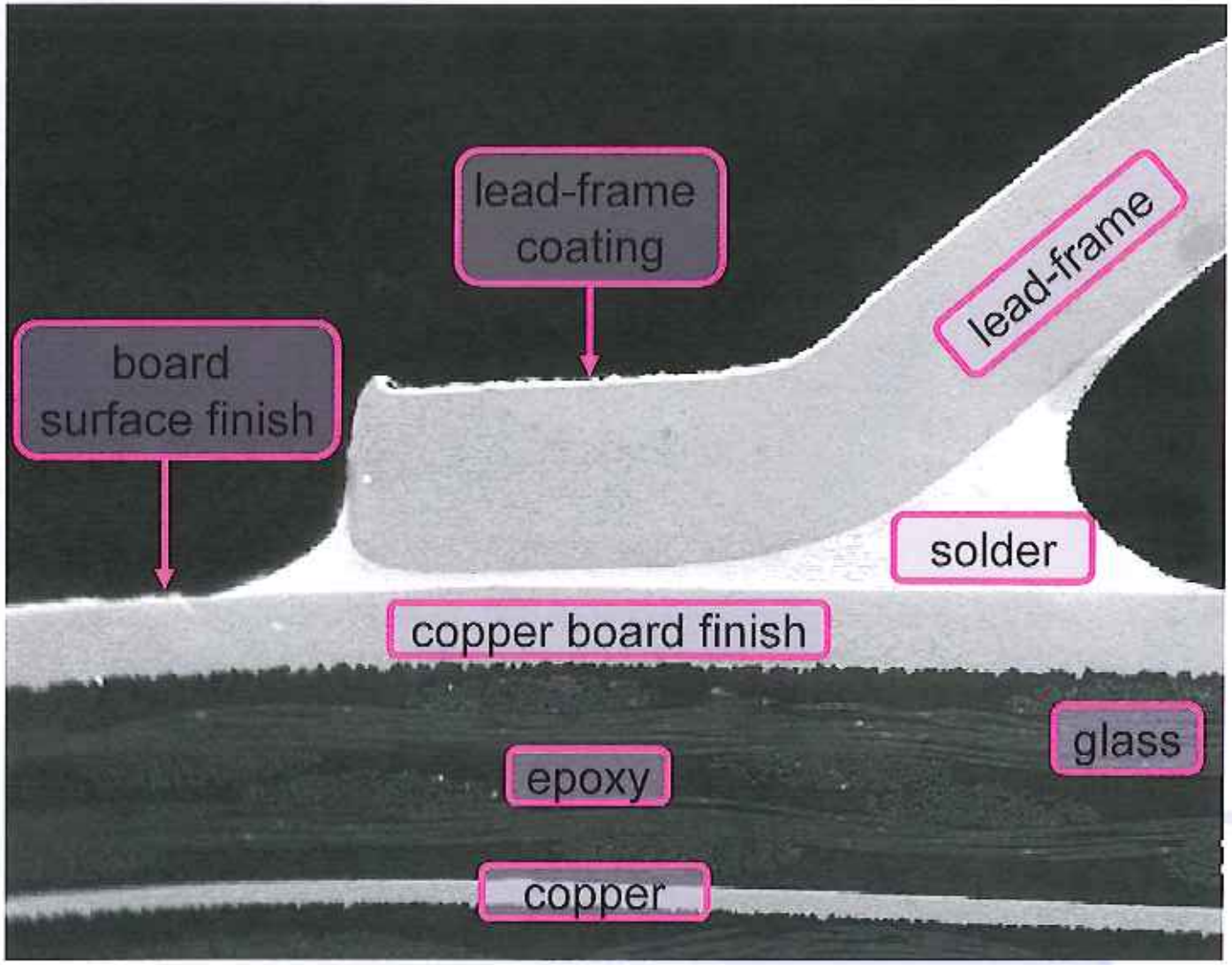

Where banned substances might be?

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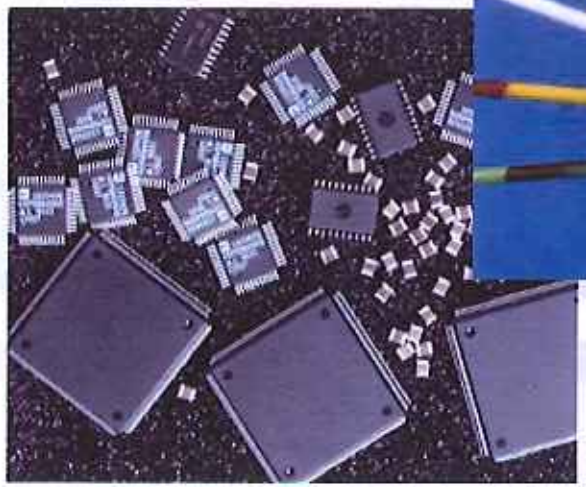
- Mechanical fixings – may be Zn plated with hexavalent Cr used as a passivation layer
- Plastics – may contain Pb, Cd or PBDE
- Components – may have Pb on surface finish or as internal connections
- Etc !



Analysis techniques - examples

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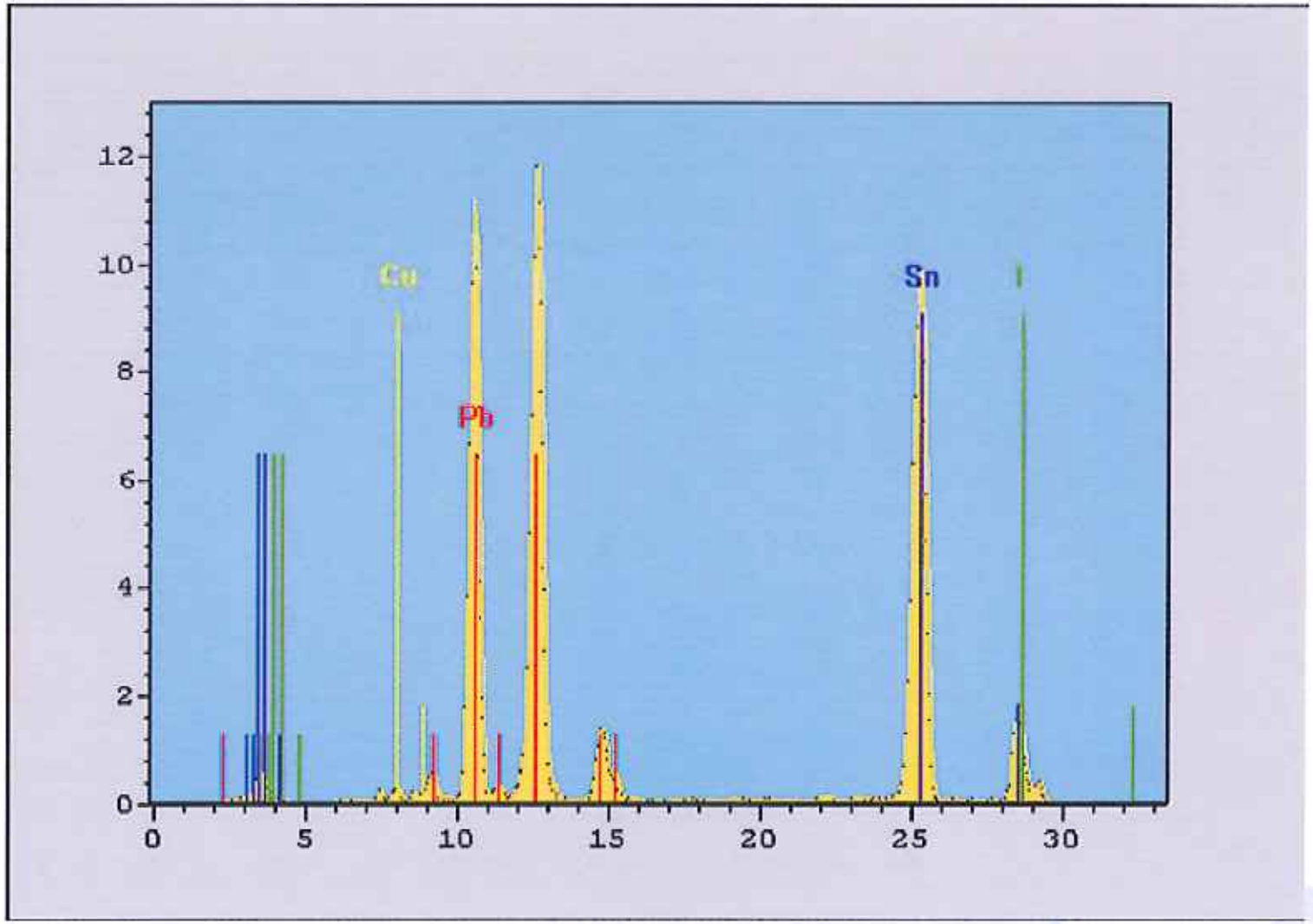
Technique	Substances	Comments
AAS	Pb, Cd, Hg, total Cr	Dissolve components or material
ICP	Pb, Cd, Hg, total Cr	Dissolve components or material
ED-XRFA	Pb, Cd, Hg, total Cr and Br	Useful surface analysis method –has limitations
SEM-EDX	Pb, Hg, total Cr and Br	Surface analysis – useful for very small features but has limitations
Visible spectroscopy	Hexavalent Cr	Dissolve coating to form coloured solution
GCMS	PBB & PBDE	Various options

DTI Report Compliance, 2004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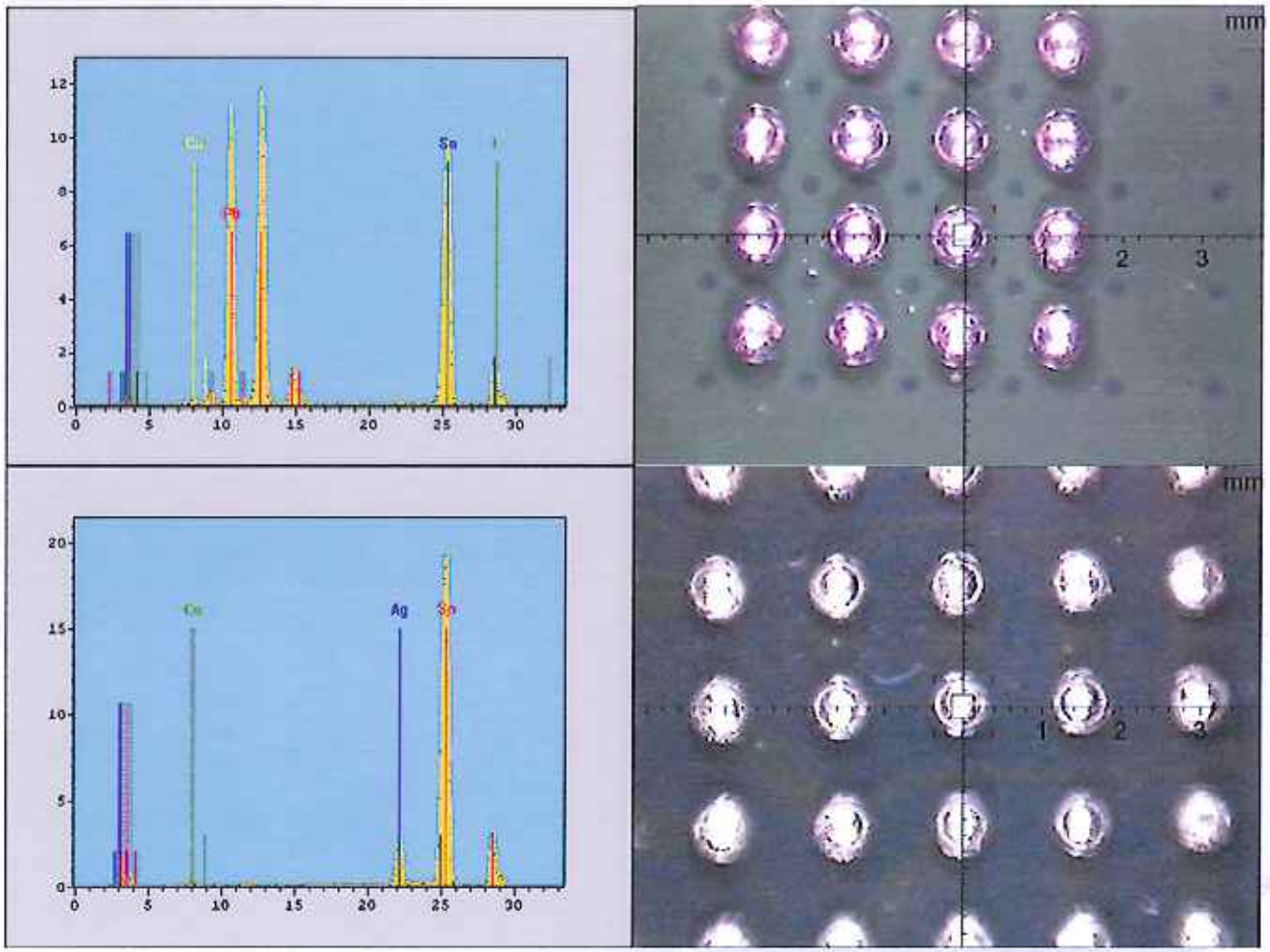
Cu
Pb
Sn
Cu
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Sn
mm
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Banned Substances

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- Pb in solders, PCB finishes, component terminations.
- Hg in Switches, lamps, thermostats & sensors
- Cd in switches, springs, pigments, housings & batteries
- Cr(VI) as anticorrosion coating and wood preservatives
- Brominated flame retardants in casings (59%), PCBs (30%), connectors & relays (9%), wire & cable (2%)

- Don't just think of electronic circuits….think about the whole product; including cables, screws, housing, plugs etc

WHAT IS IN OUR OLD PRODUCTS?

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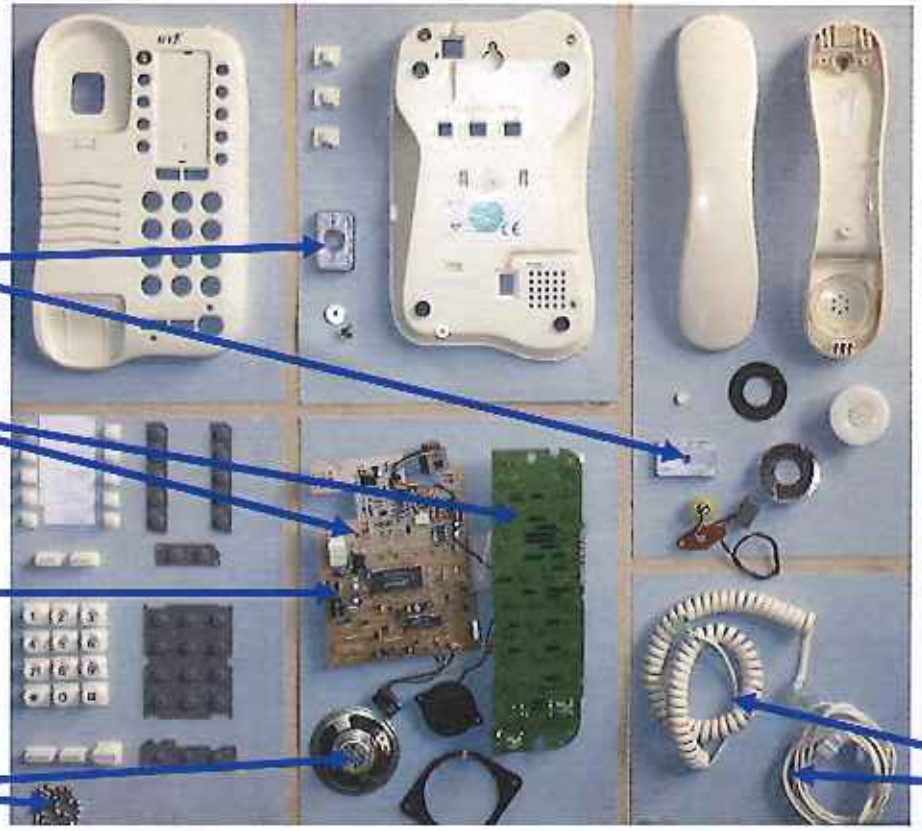
3 to 8 years old

Lead weights

Lead solder

Bromine based flame retardants

Hexavalent chrominum on screws and speaker mount



No cadmium or mercury. BT banned Cd in 1997

Lead in PVC

WHAT IS IN OUR OLD PRODUCTS?

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1 to 3 years ago

No cadmium or mercury in product.

No lead stabilisers in cordage

No lead weights

Hexavalent chromium on screws

Lead solder and Bromine based flame retardants

Conclusions

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- Lead-free solder joints look subtly different, IPC-A-610D
- Need to control materials used on site between RoHS compliant and non-compliant
- As solder joints become smaller X-ray inspection plays an ever more important role in inspection.
- Tests are available to screen for compliance.
- Once compliant; records need to be kept for 4 years.