The X-Factor - How X-ray Technology is Improving the Electronics Assembly Industry

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Summary for today

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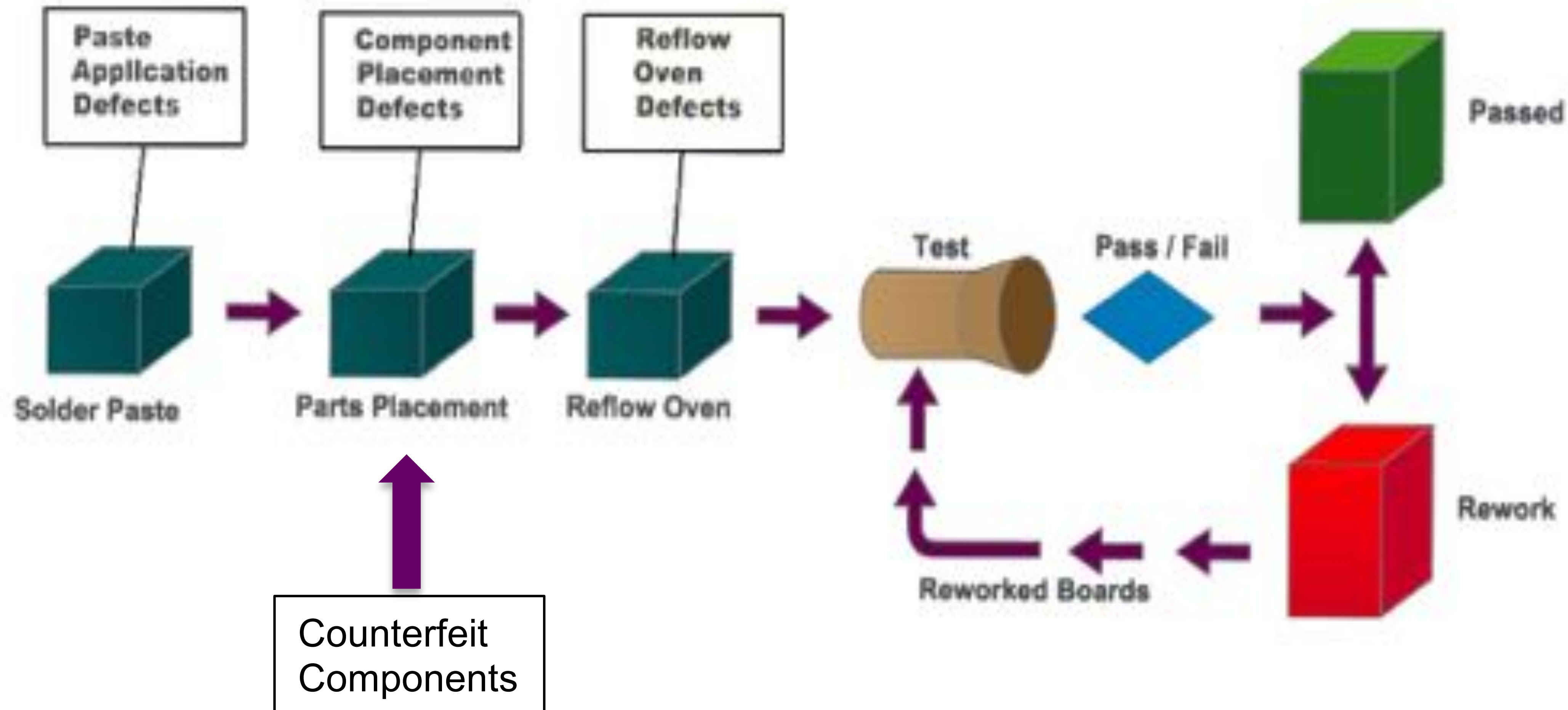
1. Electronic component inspection and failure analysis.
2. Component counting and material management.
3. Reverse engineering.
4. *Counterfeit detection.*
5. Real-time defect verification.
6. Computed tomography (CT) techniques and how to differentiate between 2D, 2.5D, and 3D x-ray inspection.
7. Design for manufacturing (DFM) and design for x-ray inspection (DFXI).
8. Voids, bridging, and head-in-pillow failures in bottom terminated components (BTC).
9. Artificial Intelligence and x-ray inspection

Where Are Defects Introduced?



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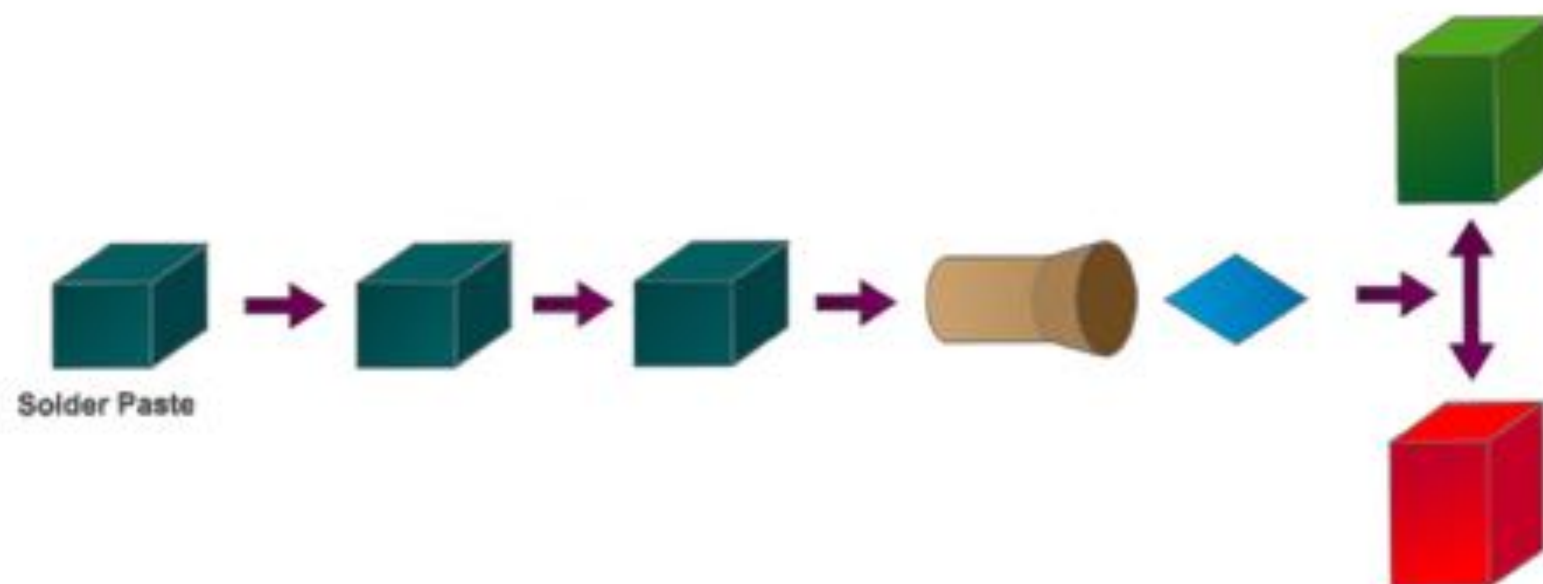
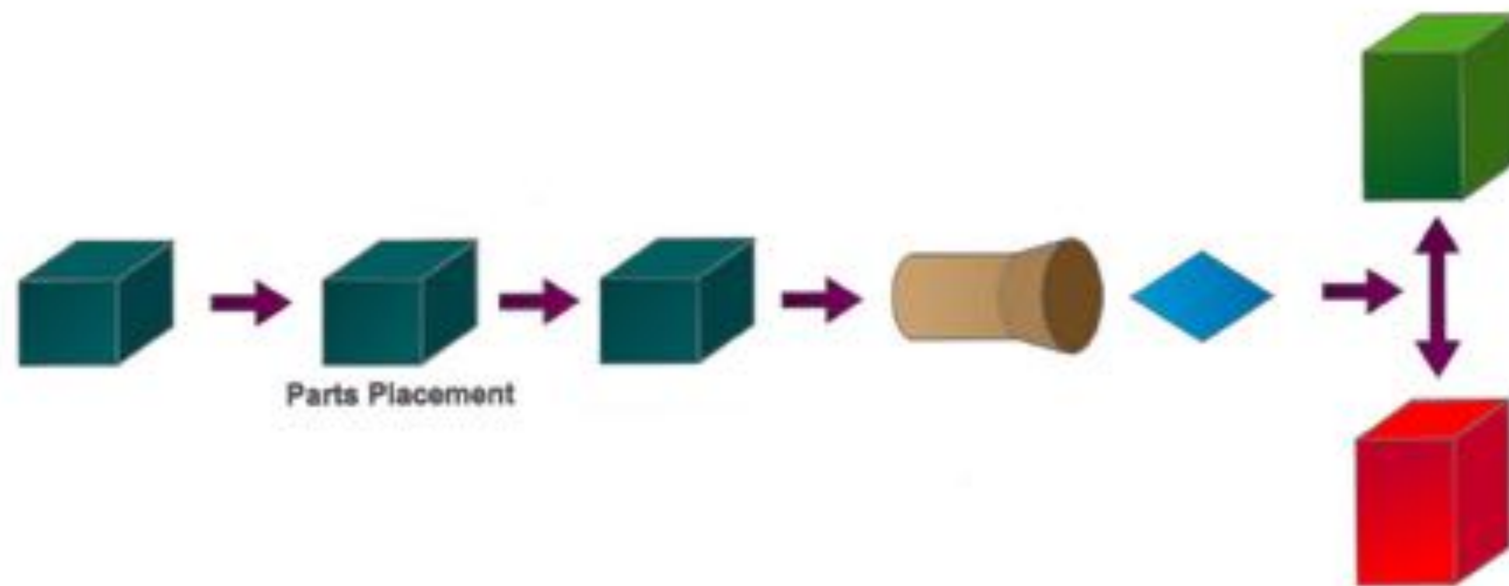
Solder Paste Application Defects

- Defects associated with paste application
  - Excess solder
  - Solder bridges
  - Insufficient solder



Component Placement Defects

- Defects associated with component placement
  - Misalignment
  - Polarity
  - Missing component



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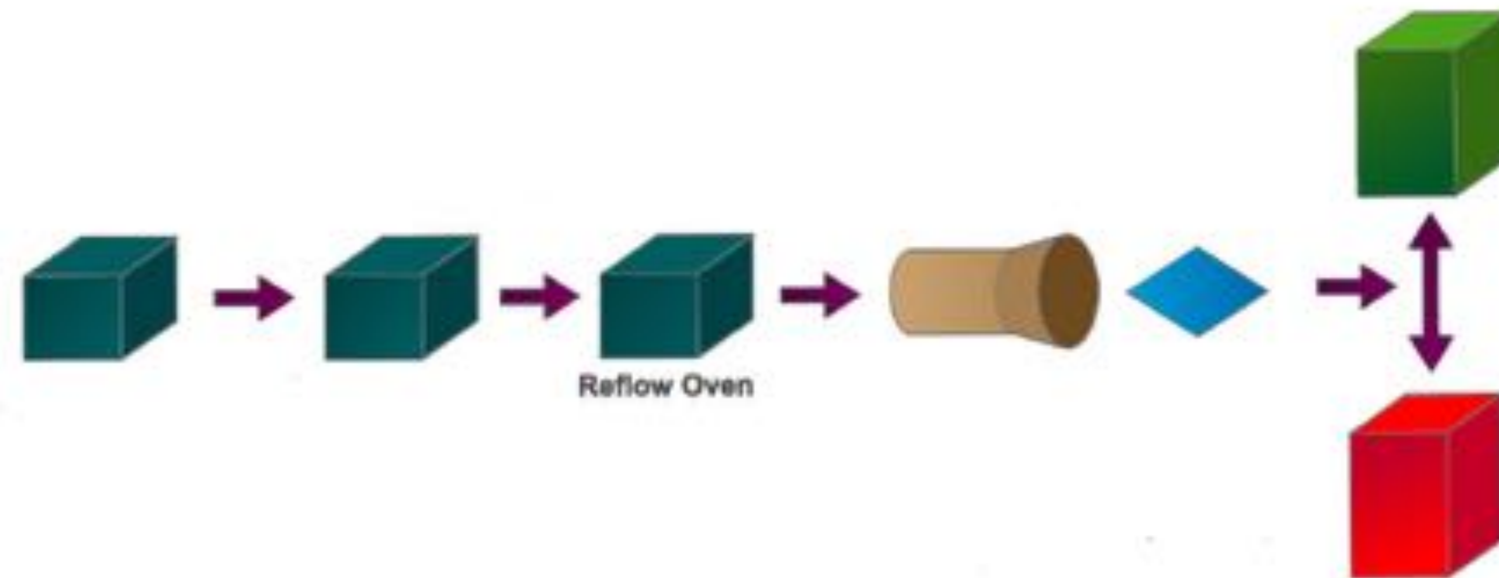
Reflow Oven Defects

- Defects associated with the reflow profile
  - Voiding
  - Bridging
  - Solder balls
  - Excess solder
  - Insufficient solder



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Statistical Process Control

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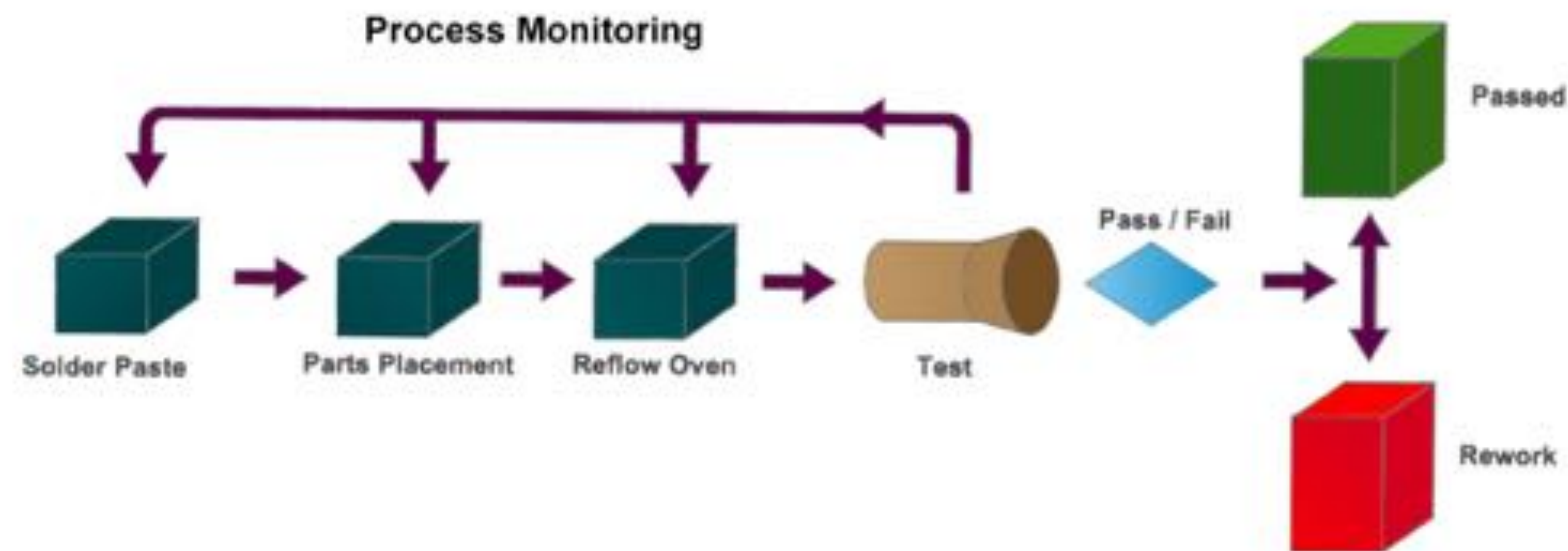
- Manufacturing process quality assurance.
  - Solder joint measurement data, collected during x-ray test, can be statistically analyzed to identify manufacturing drifts, trends and other relevan



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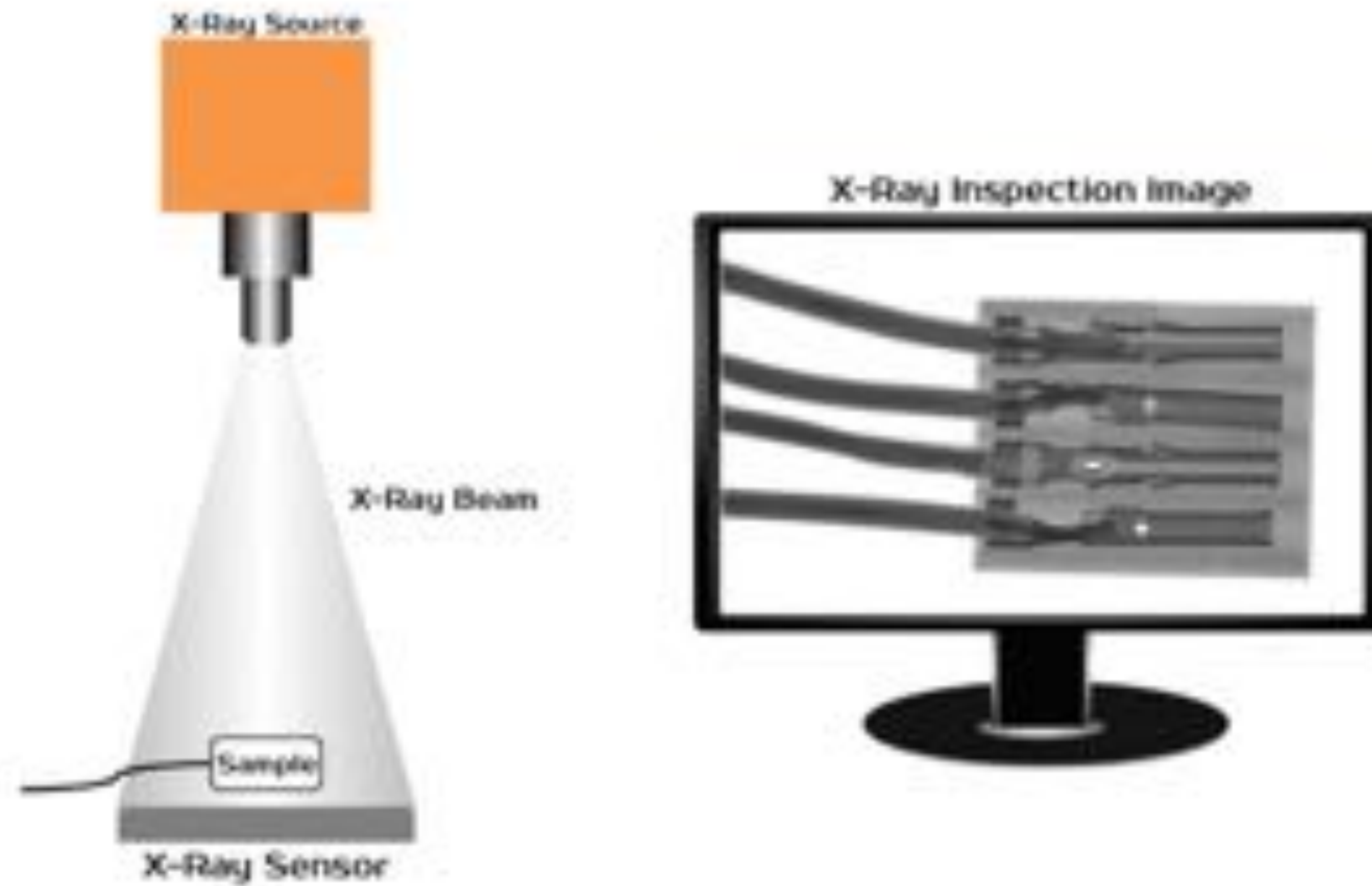
Principles of x-ray inspection



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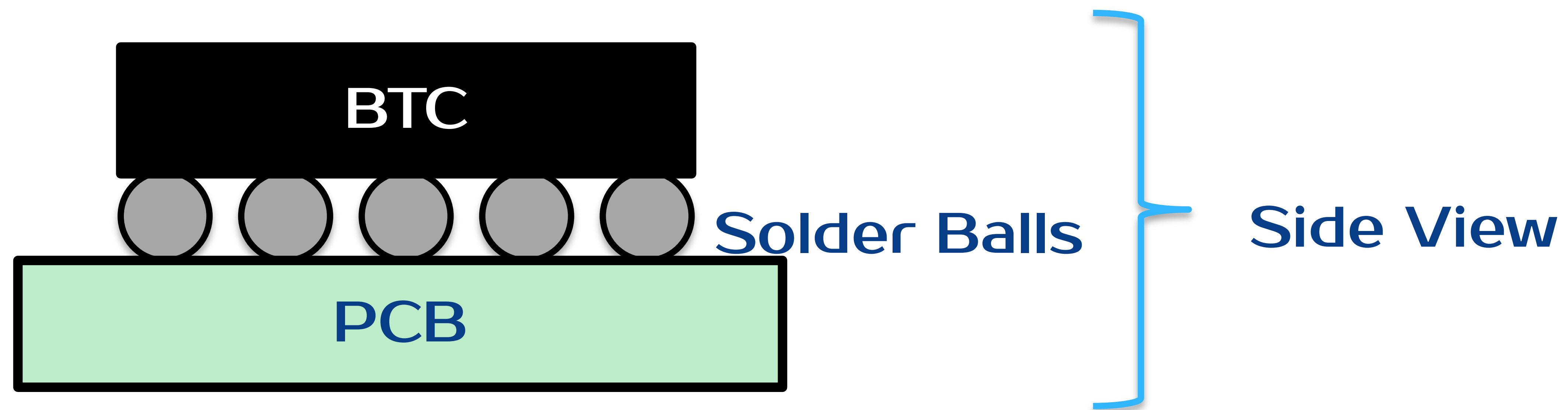
X-ray imaging 101: the bottom terminated component, side view



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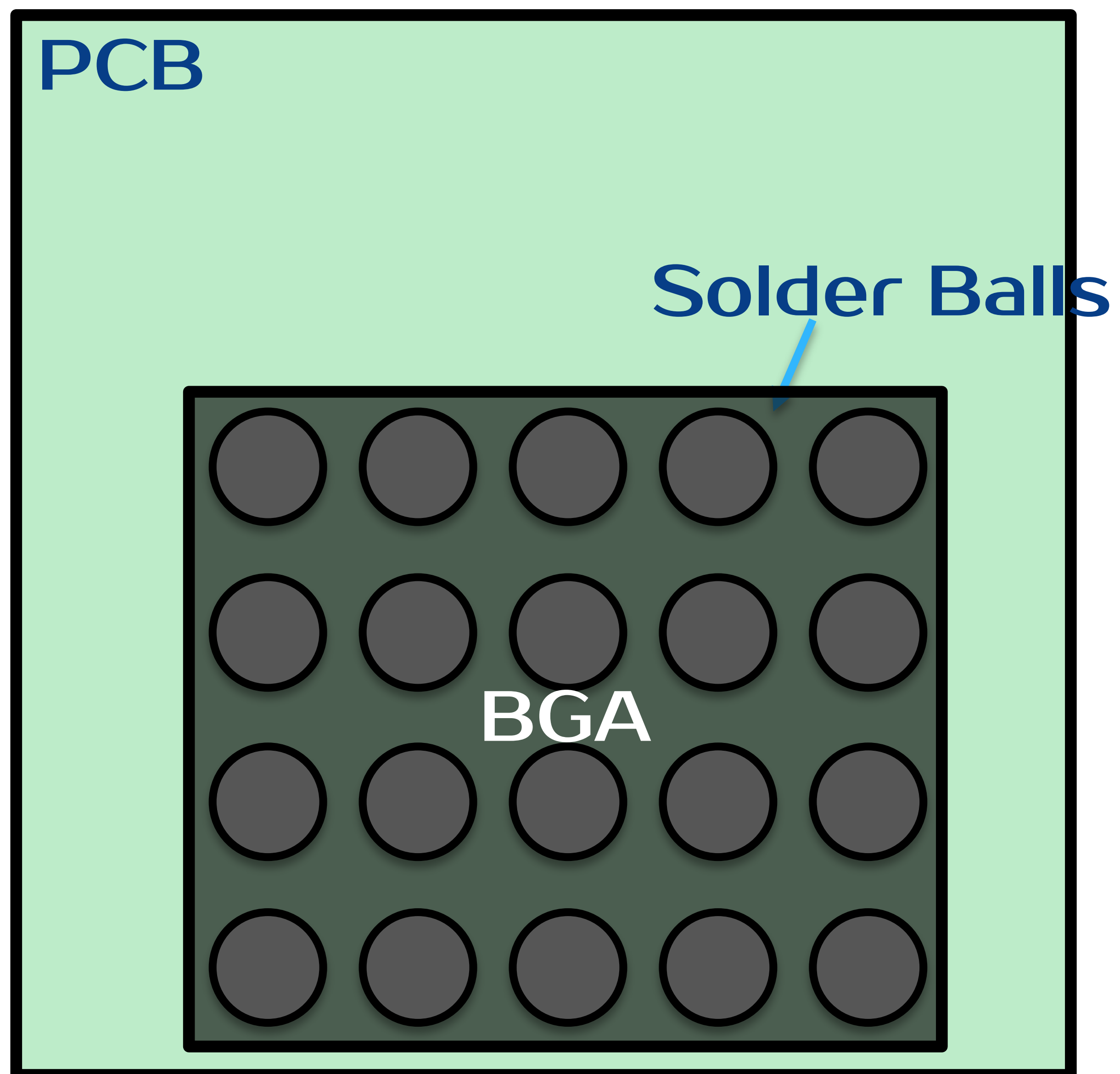
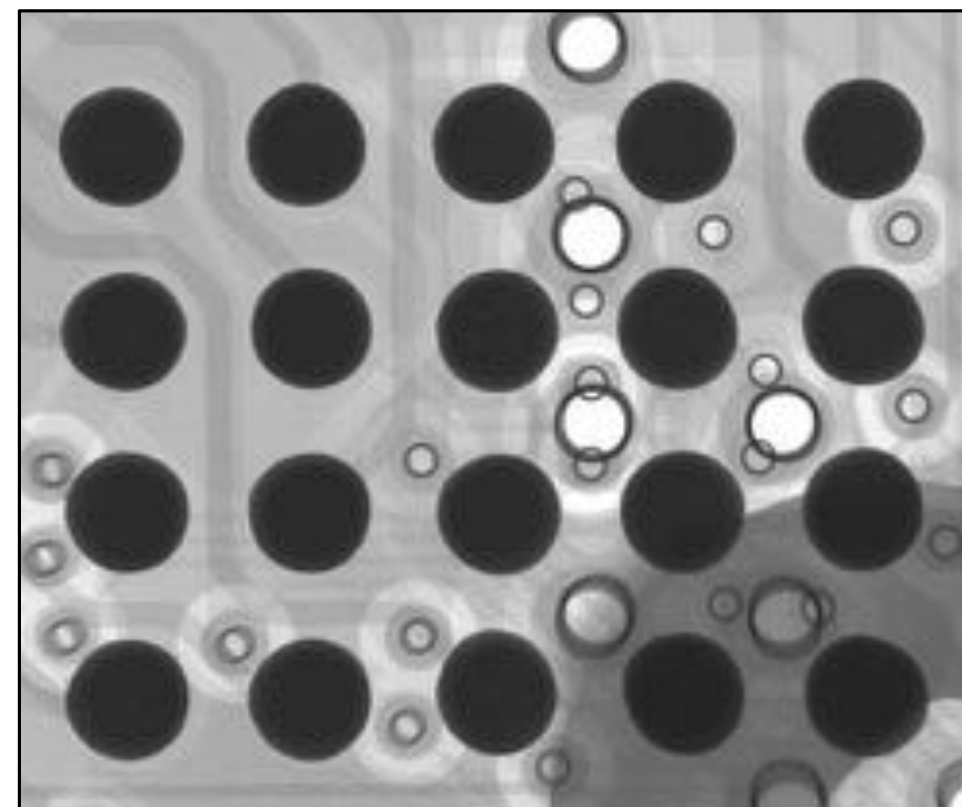
X-ray imaging 101: the BGA, top view



X-ray image of BGA



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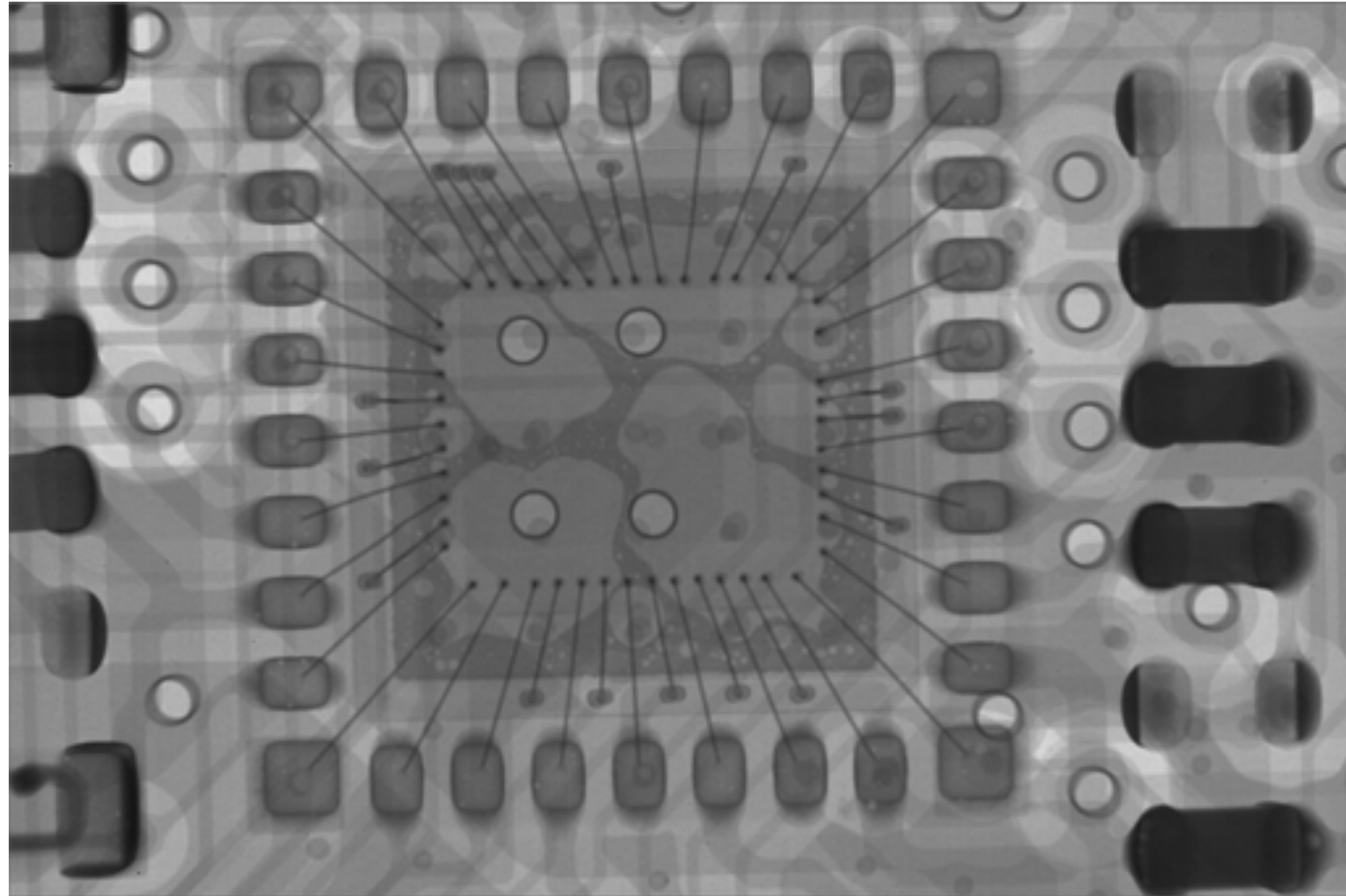
QFN assembly with excess voiding



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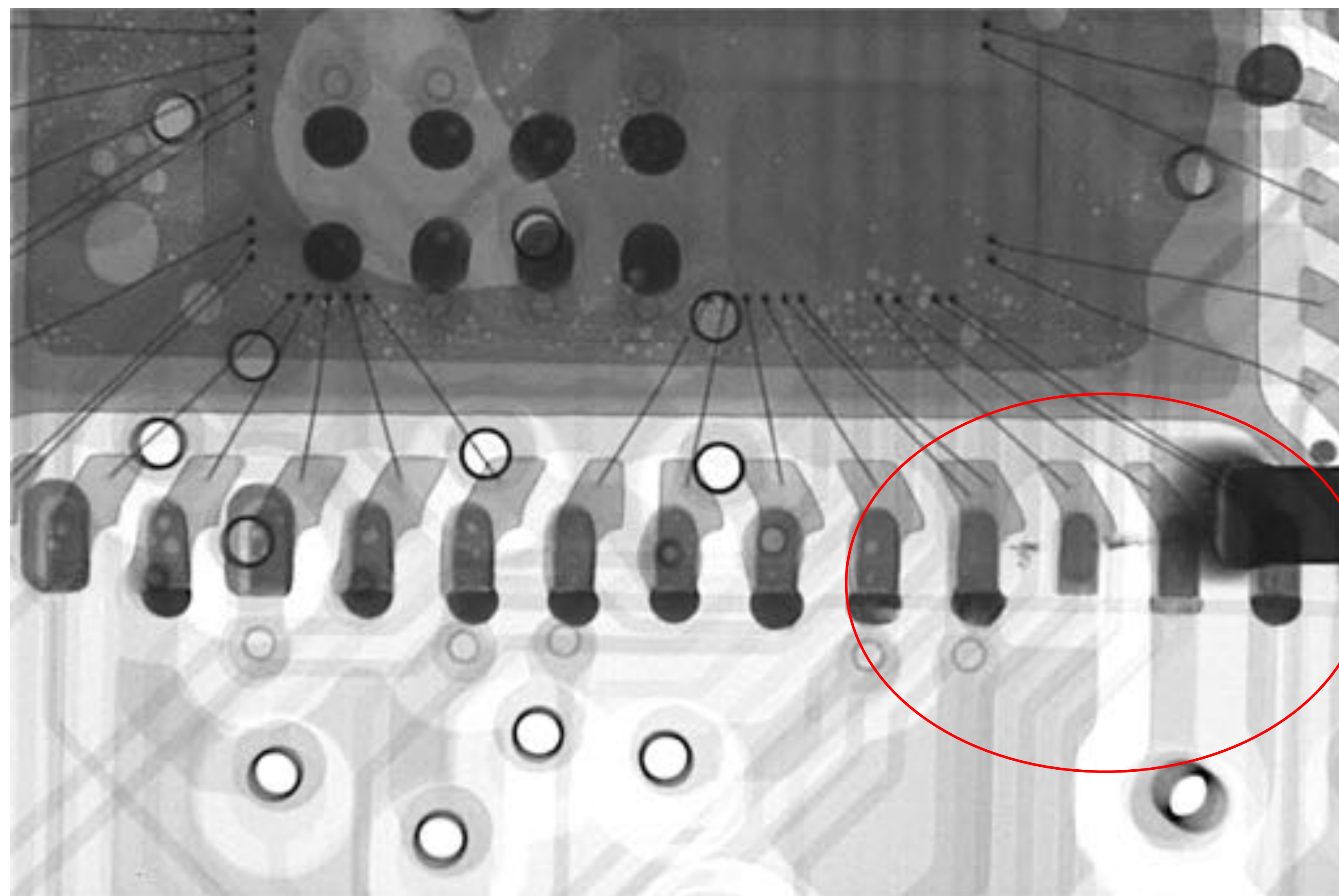
Detail of open pin in QFN package



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Void Measurement

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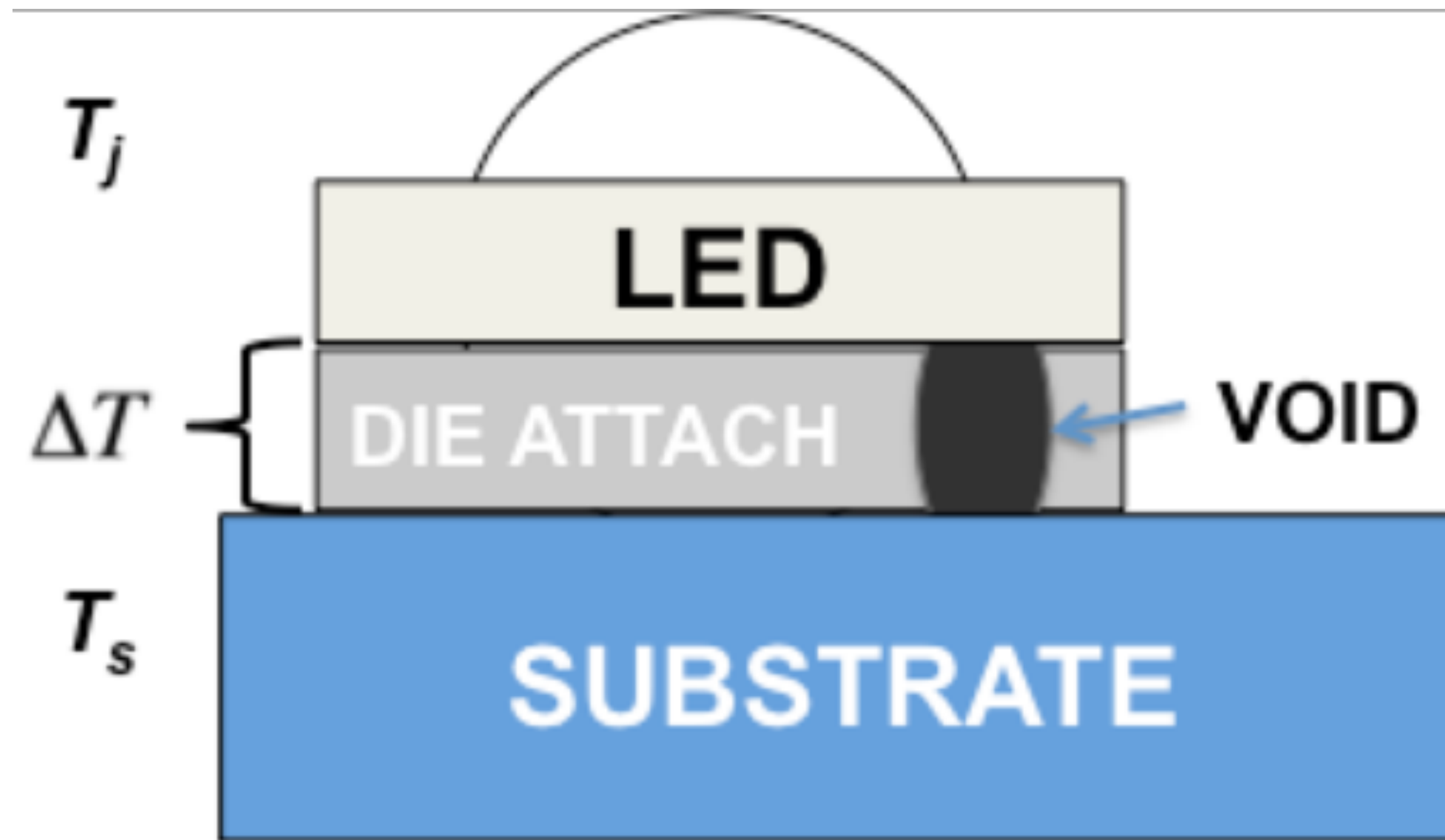
Solder voids in LED assembly



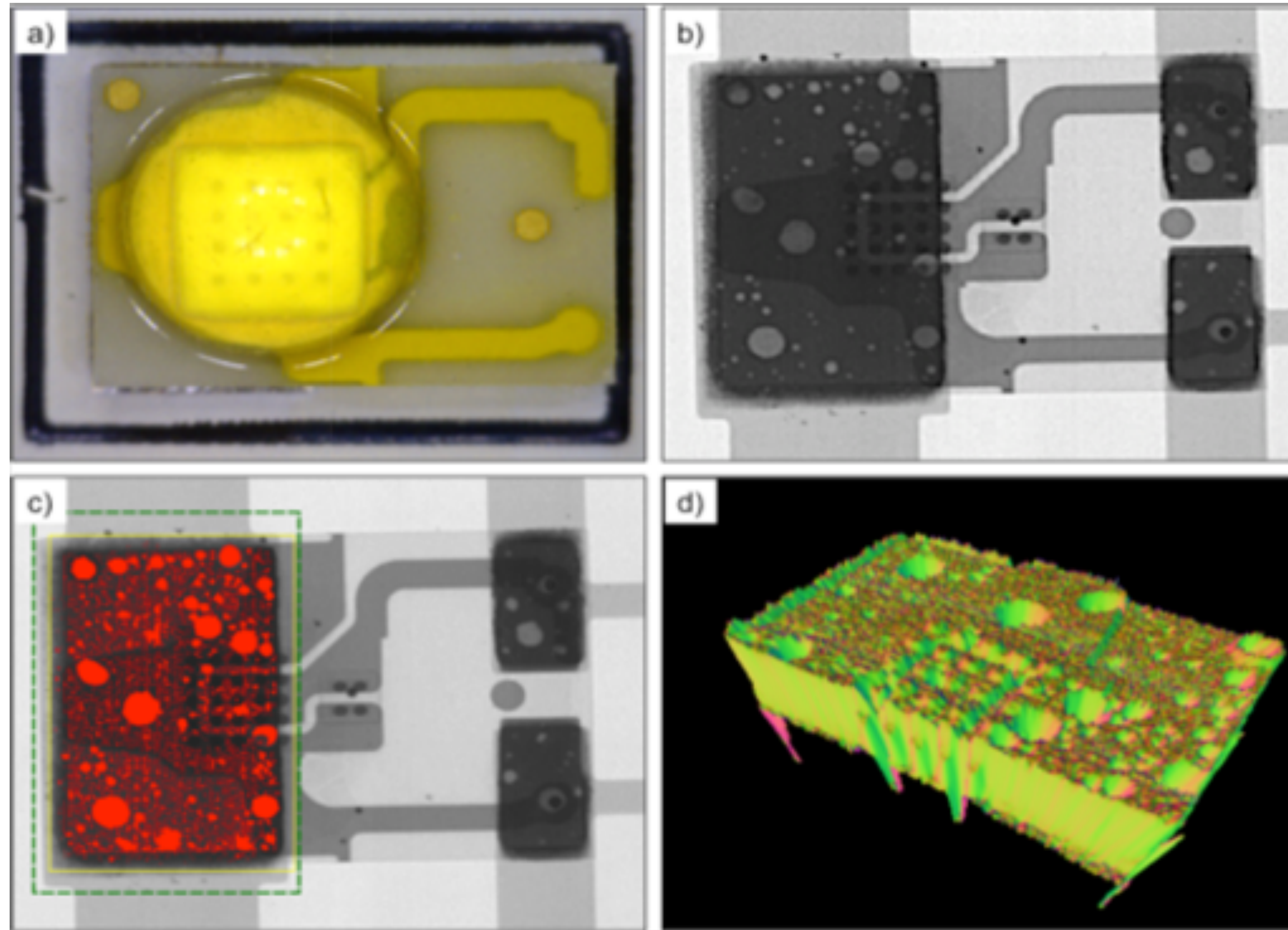


Figure 2 – a) Photo of LED assembled onto substrate, b) x-ray inspection image of LED, c) x-ray inspection image with identified and measured voids using TruView software, d) 3D rendering of die attach voids

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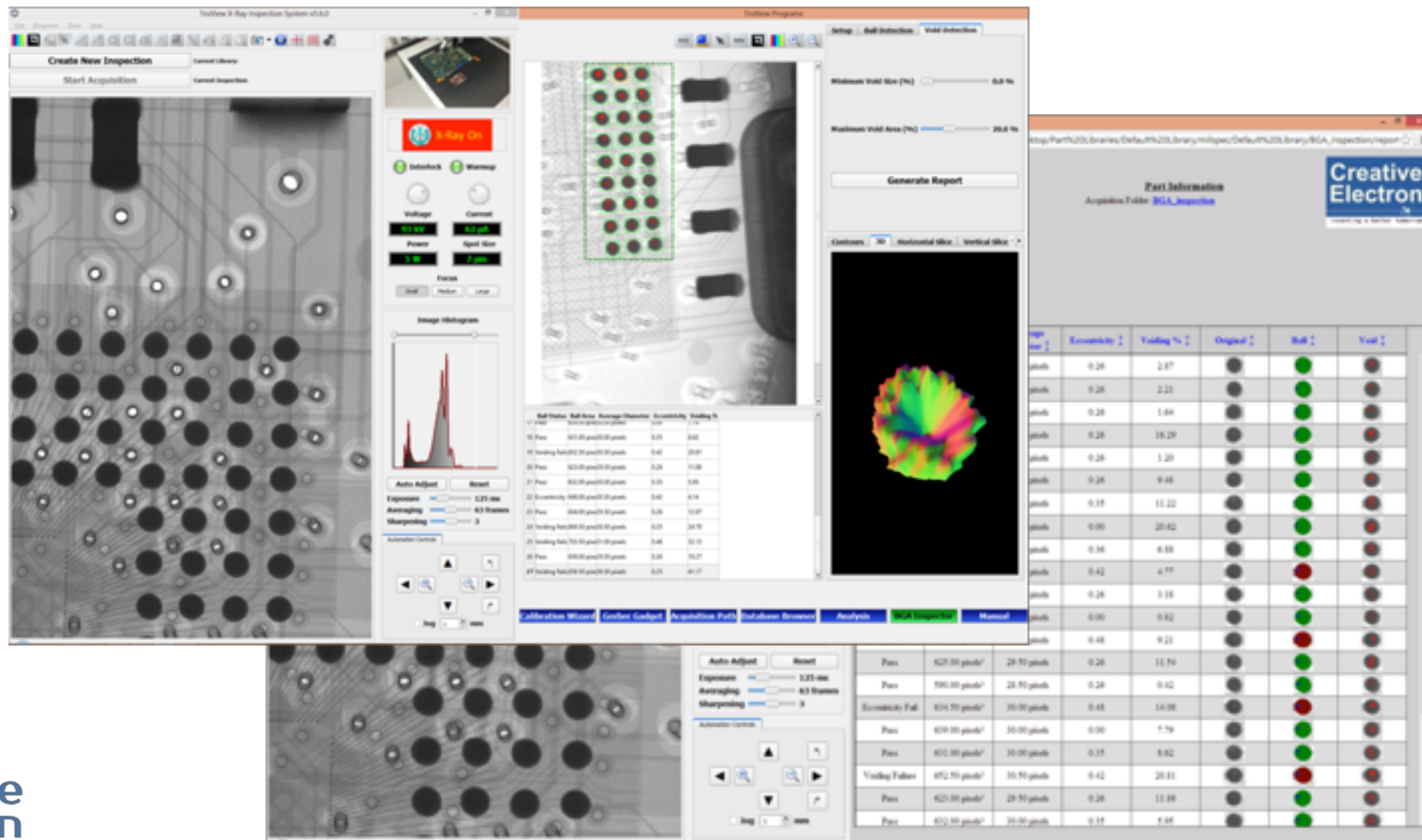
BGA Inspector



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Dual Energy

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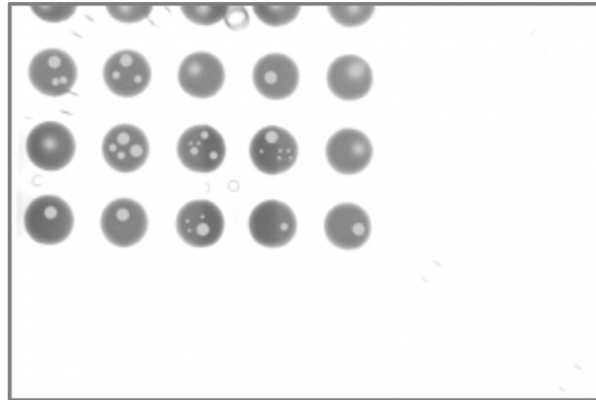
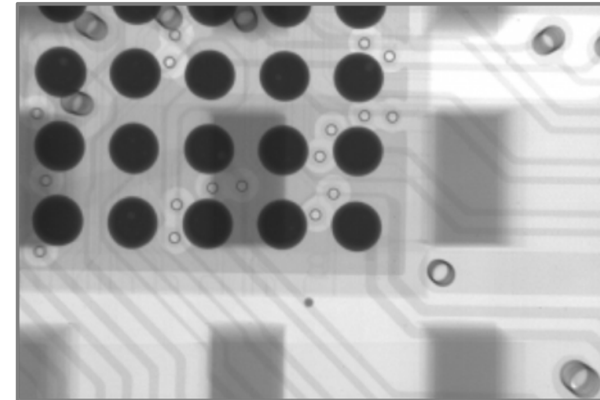
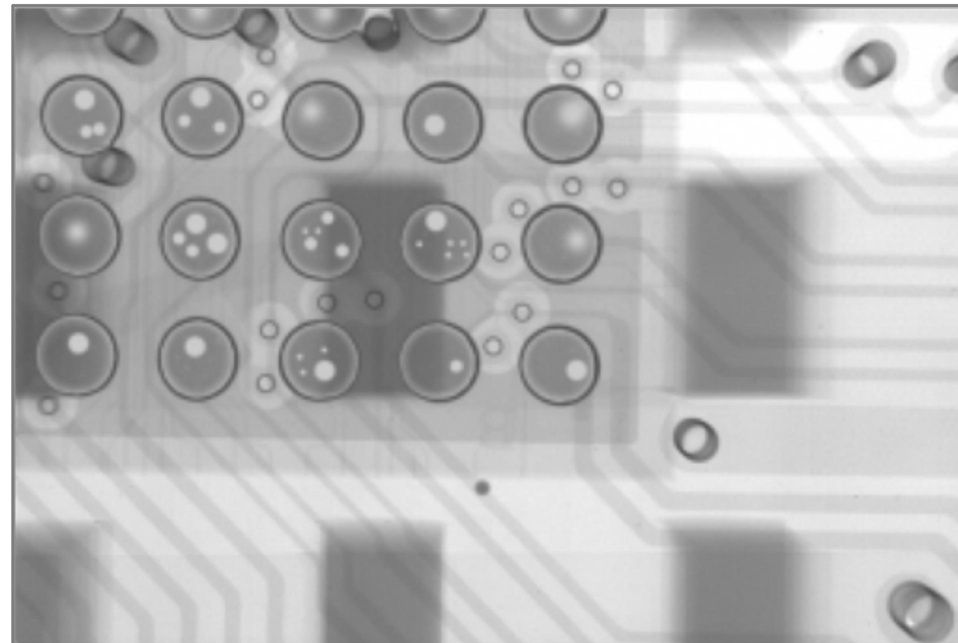
High Energy Image



Low Energy Image



Dual Energy Image



PATENT PENDING

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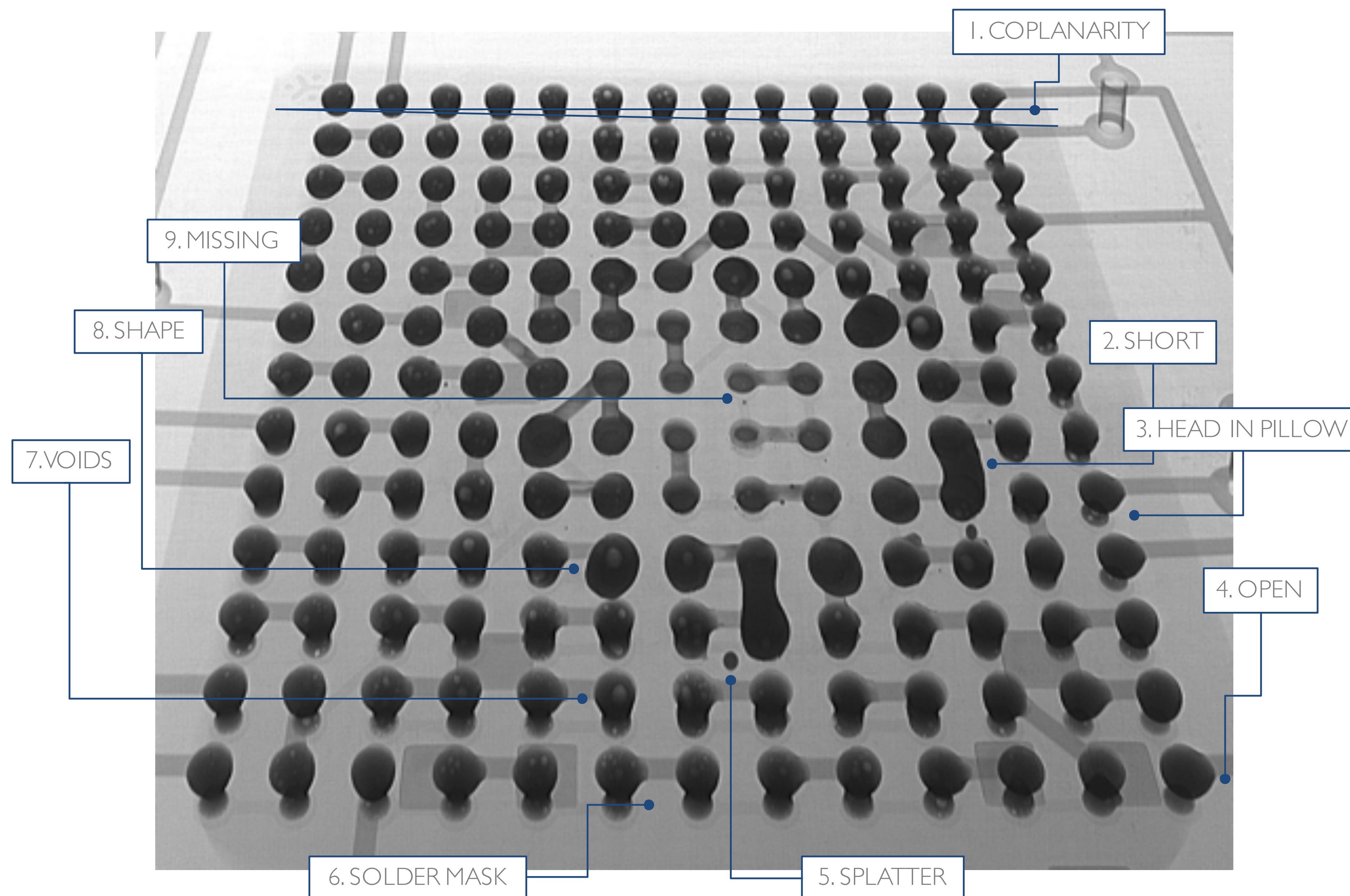
The best – and worse – BGA assembly



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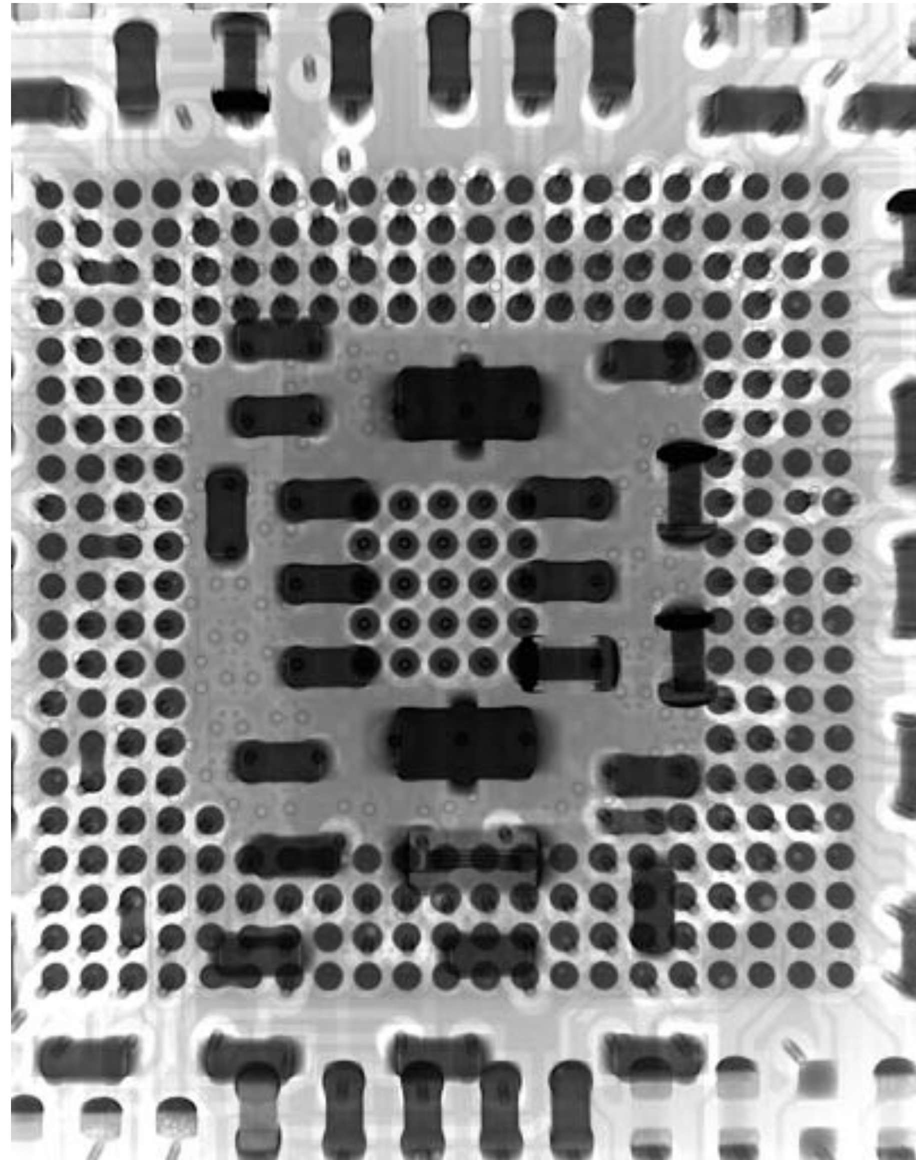
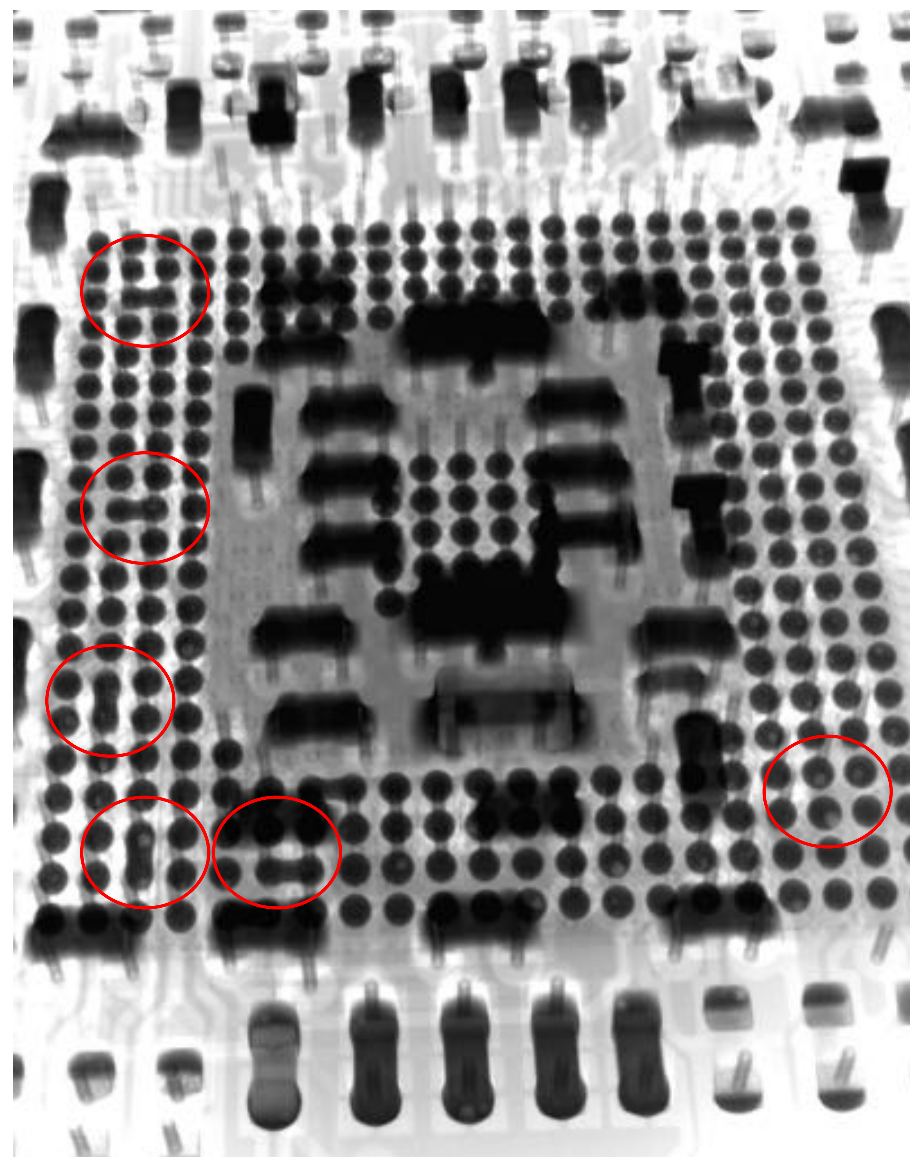
Design For Inspection: Think 3D!

- Components on both sides of board align in such a way it's difficult to assess defects
  - Overlapping BTC
  - Caps under QFN and BGA
  - Heat sinks
- How to avoid it
  - ($) Design for Inspection
  - ($$) 2.5 or ($$$$) 3D x-ray inspection

BGA 2D x-ray



BGA 2.5D x-ray



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So what's 3D X-Ray Inspection (Computed Tomography)?

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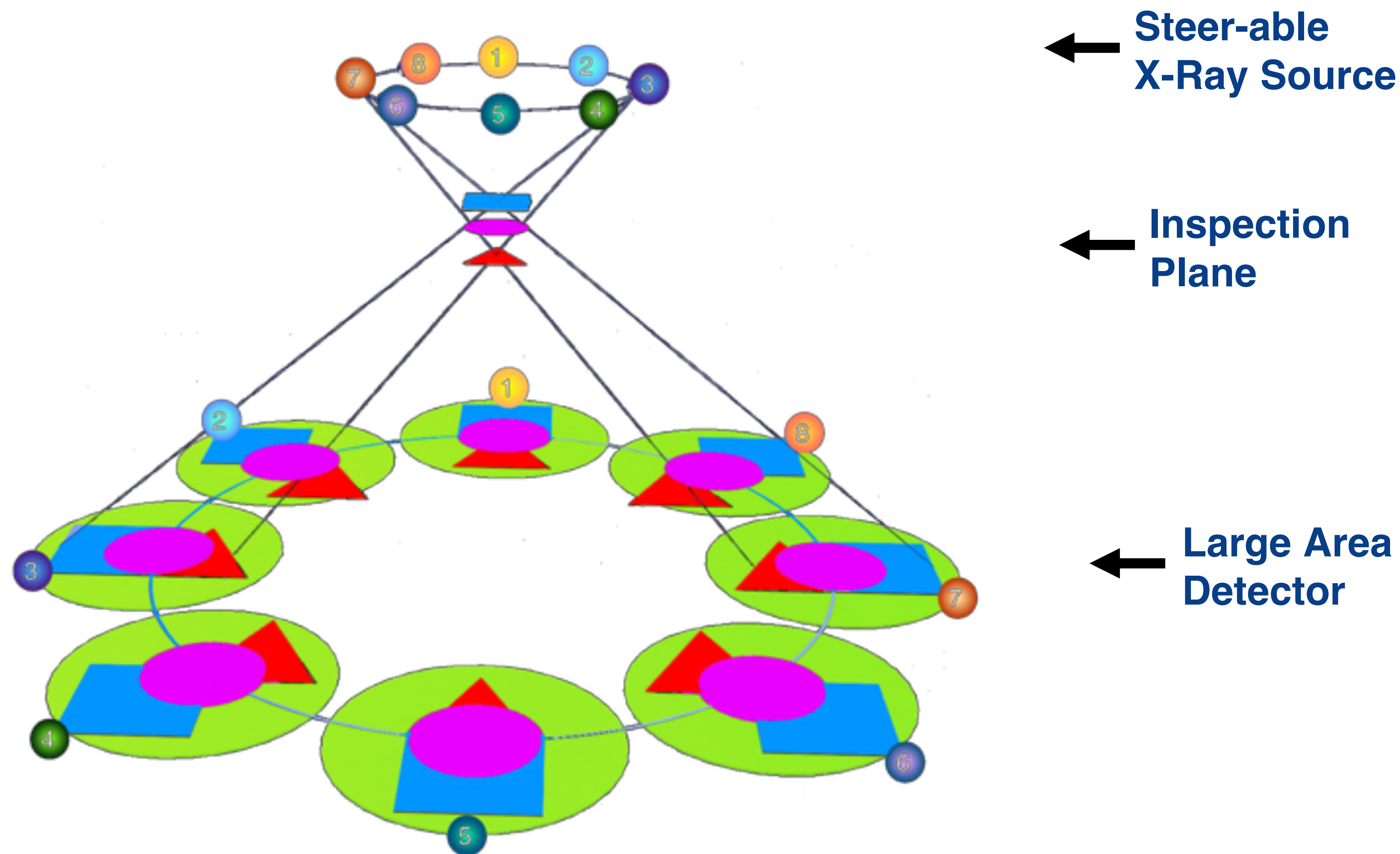
Principle of Planar CT: 3D x-ray

Multiple **Transmission** Images



Steer-able X-Ray Source

Inspection Plane

Large Area Detector

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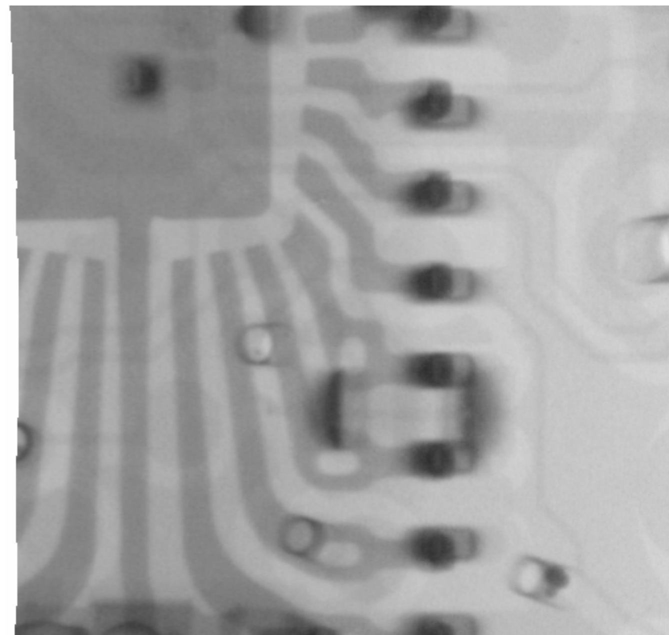
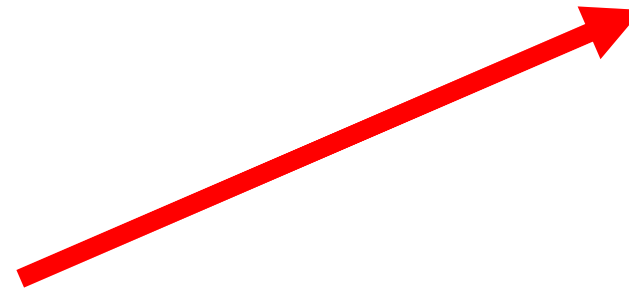
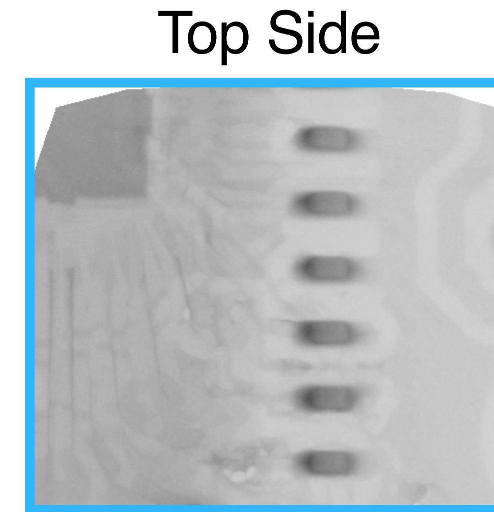
Principle of Planar CT



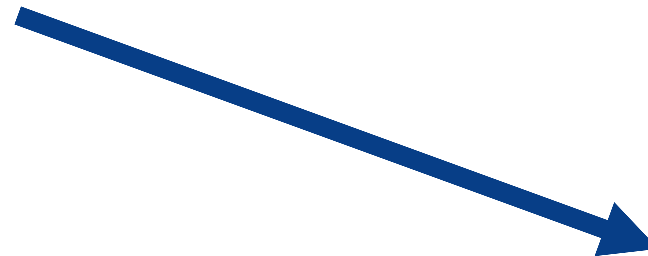
Use multiple off-axis x-ray images to separate top/bottom overlapping or obscured solder connections

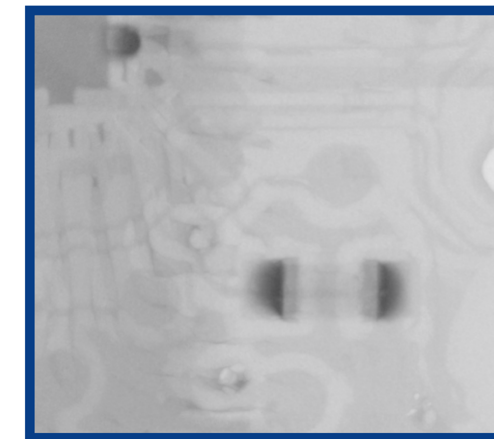


Top Side



Cross Section x-ray provides the capability to generate un-obscured views of top and bottom side components





Bottom Side

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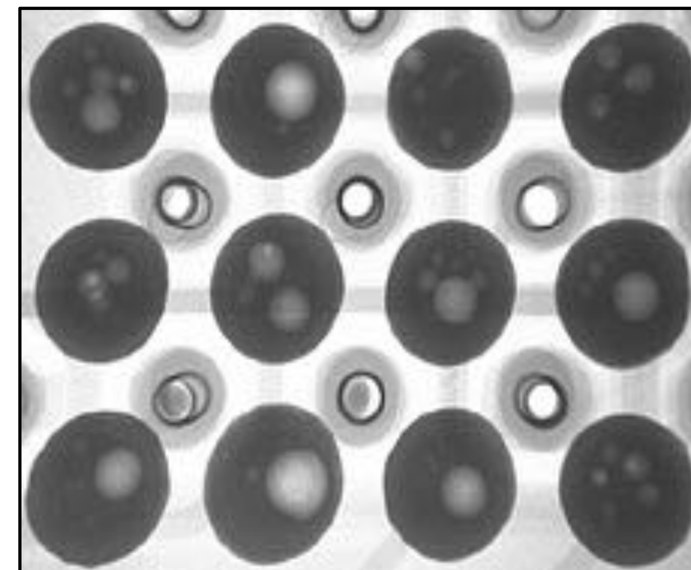
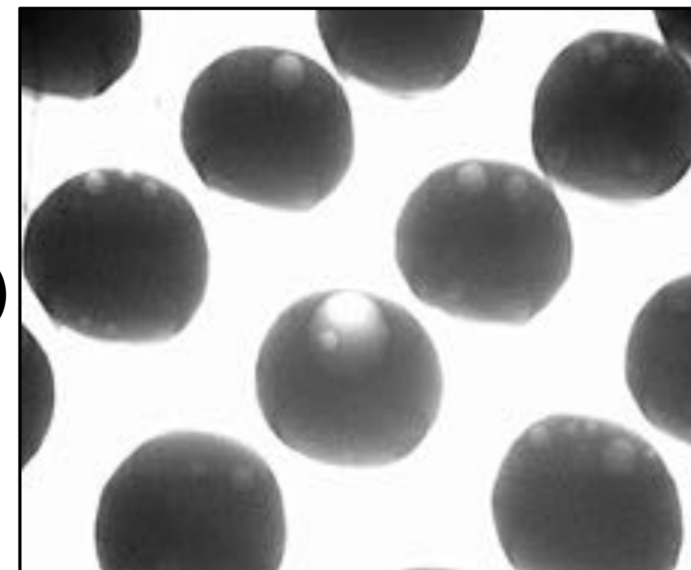
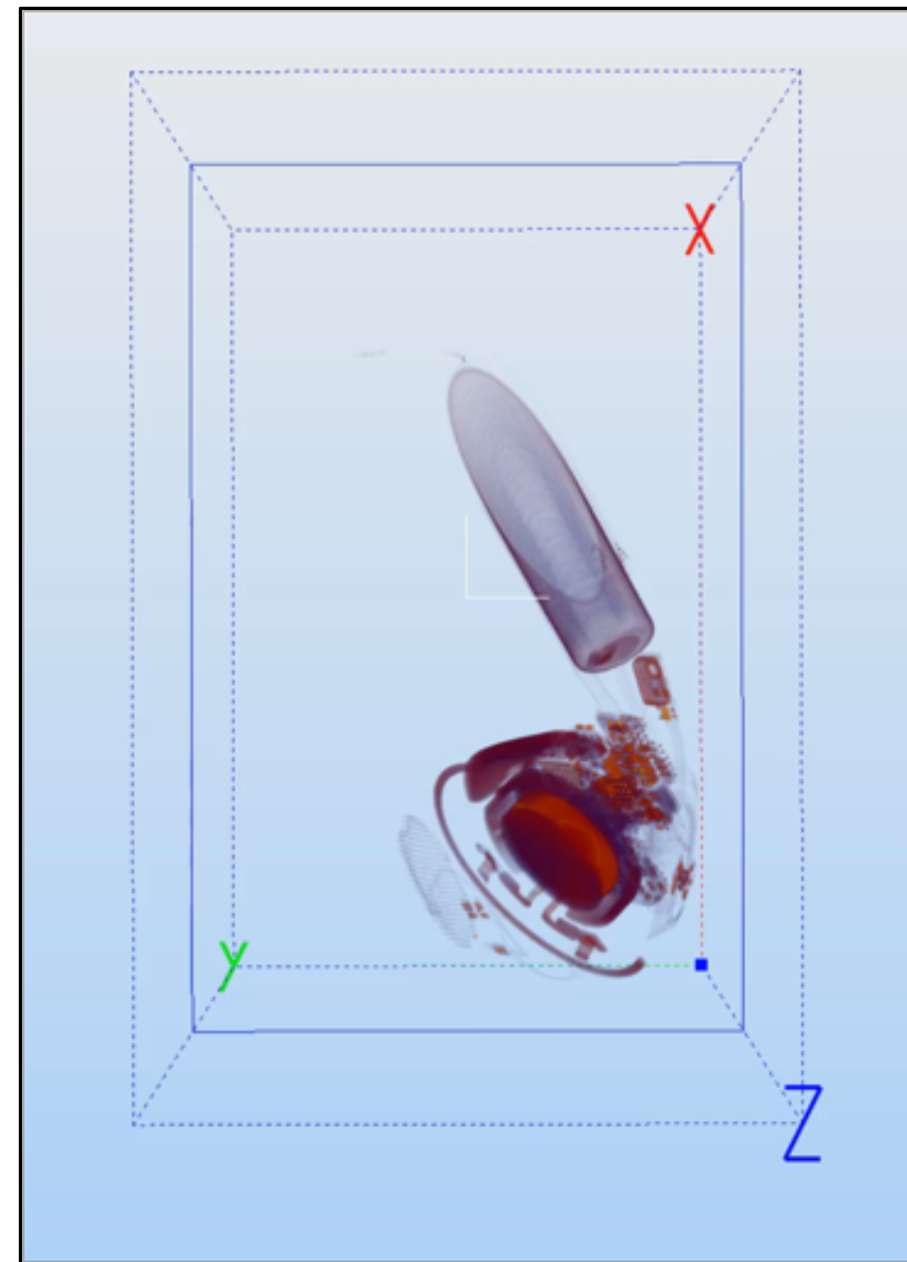
2D



2.5D



3D



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Design for Inspection

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- Think carefully about component placement when designing PCB
- Place parts so 2.5 and 3D x-ray are not needed.
- Goal is to have the whole board inspected with 2D x-ray
  - Faster
  - Better quality
  - Cheaper

Power components under BGA

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Caps under BGA

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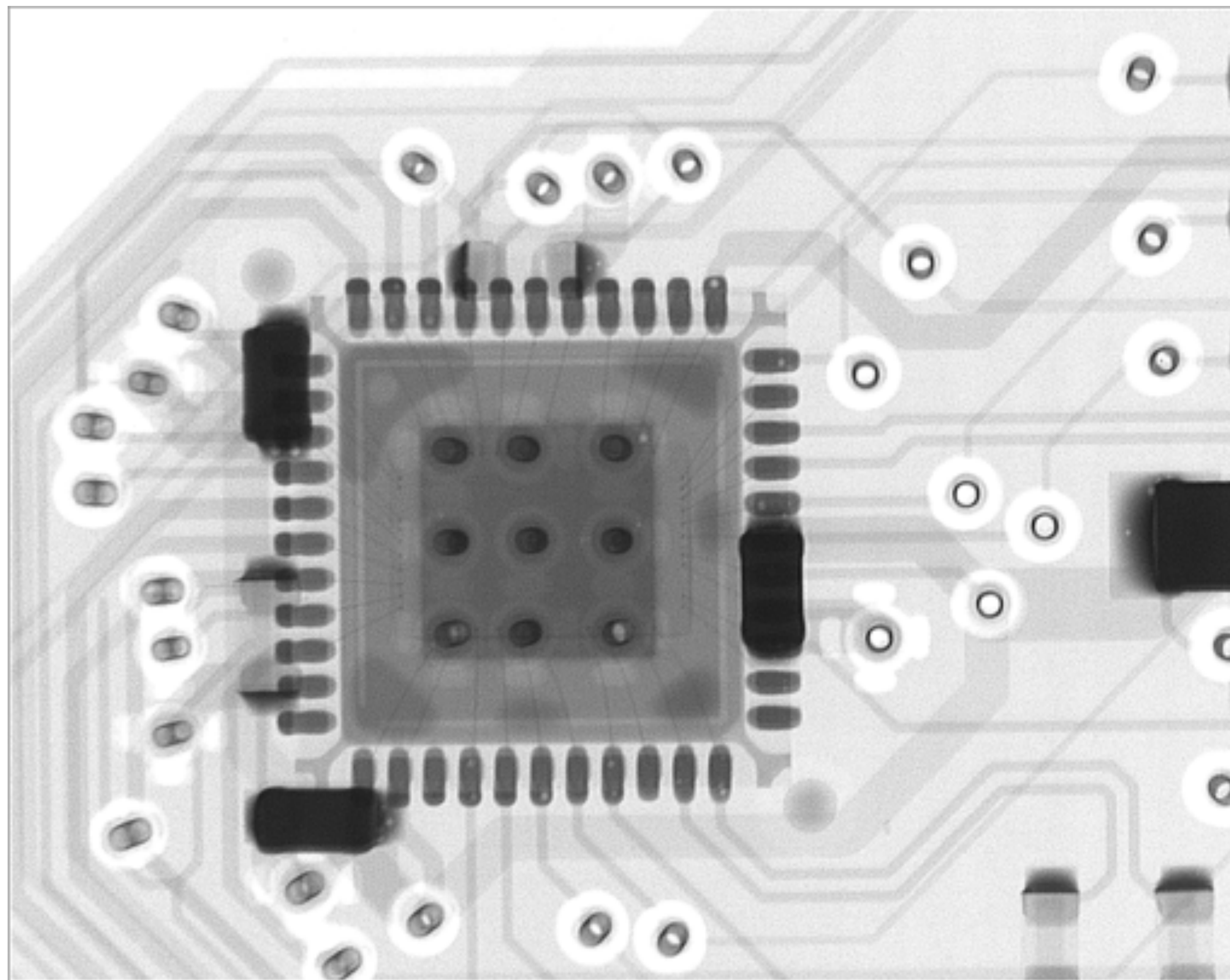
Caps under QFN leads



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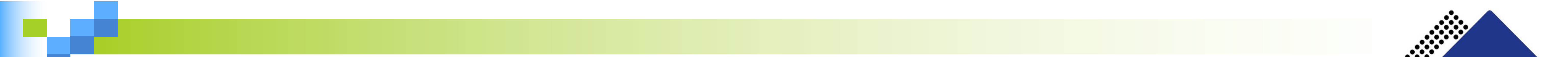
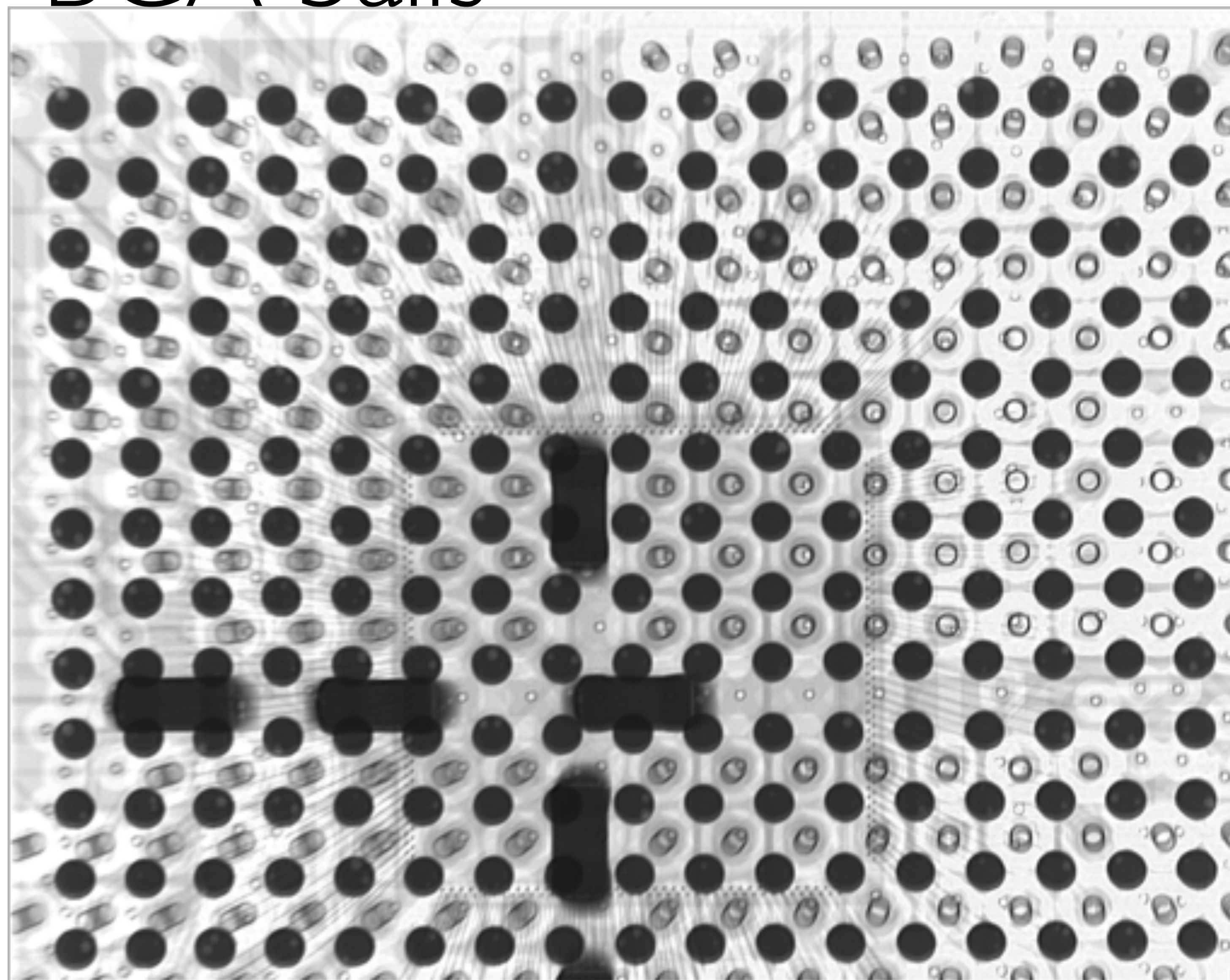


Caps under BGA balls



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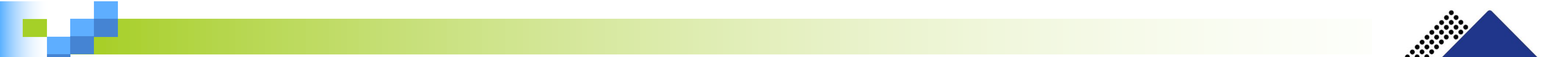

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Sample

Voiding

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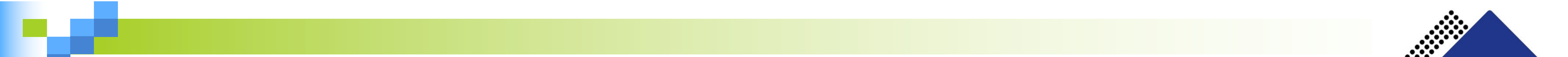

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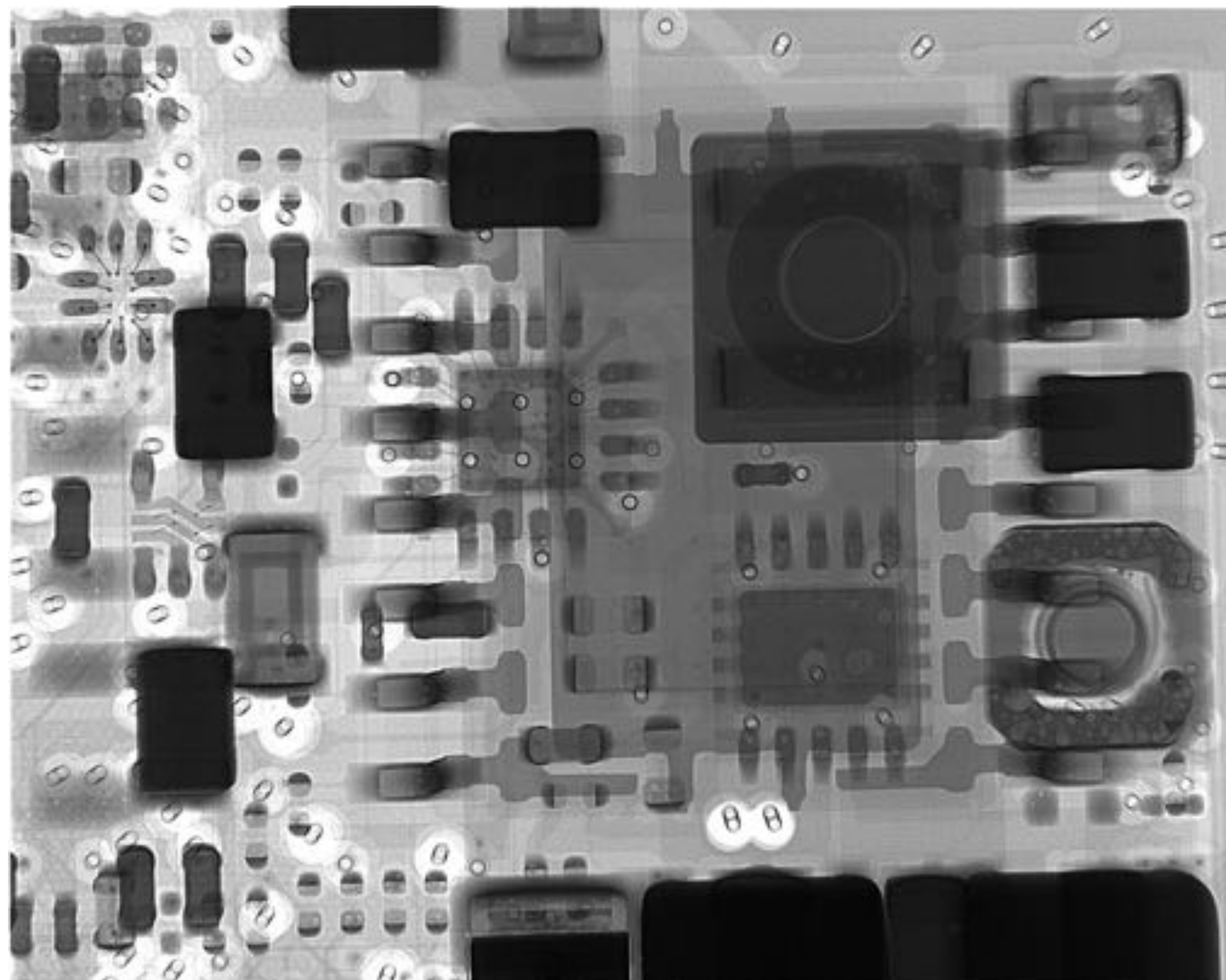
Complex construction



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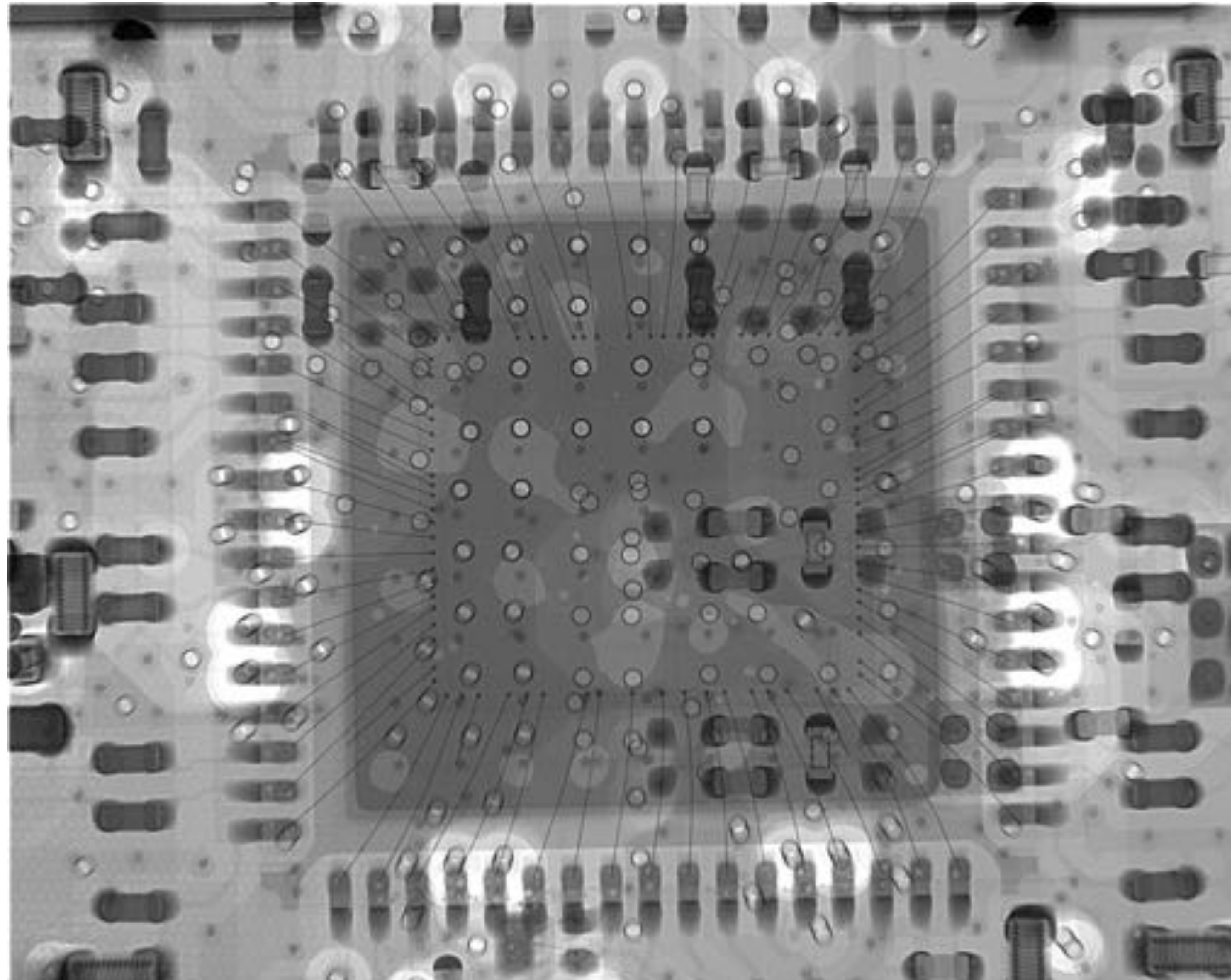
Caps and QFN



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QFN overlap

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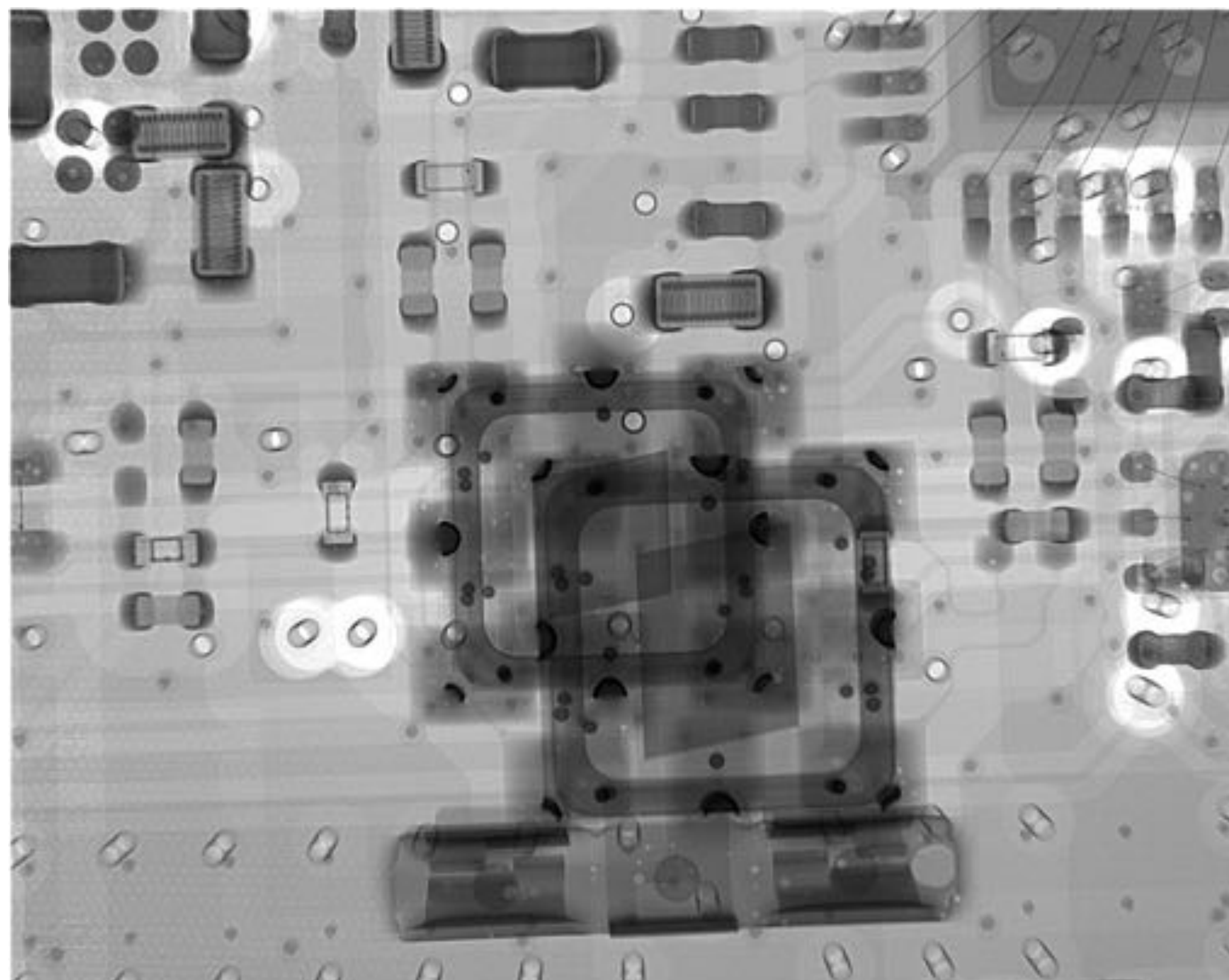

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Heat sink

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Heat sink: x-ray

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Heat sink removed: x-ray

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Think 3D!

- X-rays are a requirement when inspecting BTC
- DFM + DFI: Easier to design for inspection
- Some applications require 2.5D & 3D x-ray
- Miniaturization major driver for high resolution, high magnification, x-ray inspection

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Design for Inspection – DFI

- The right time to think about x-ray inspection is during PCB layout
- After board is assembled is too late to improve x-ray inspection ability

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Material Management & Counterfeit Electronics

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TruView^{TM} Parts Counter AI

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TruView Parts Counter : ERP & MRP

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{ REST }

ODBC

The counterfeit electronics problem

- Surplus stock of electronic components dumped into the market further establishing the broker and grey markets
- Huge amounts of scrap electronics
- Components made obsolete
- Need for short delivery time
- Massive cost reduction pressures on OEM buyers for double digit price reductions
- Buying and selling via the internet became common practice

Component Harvesting

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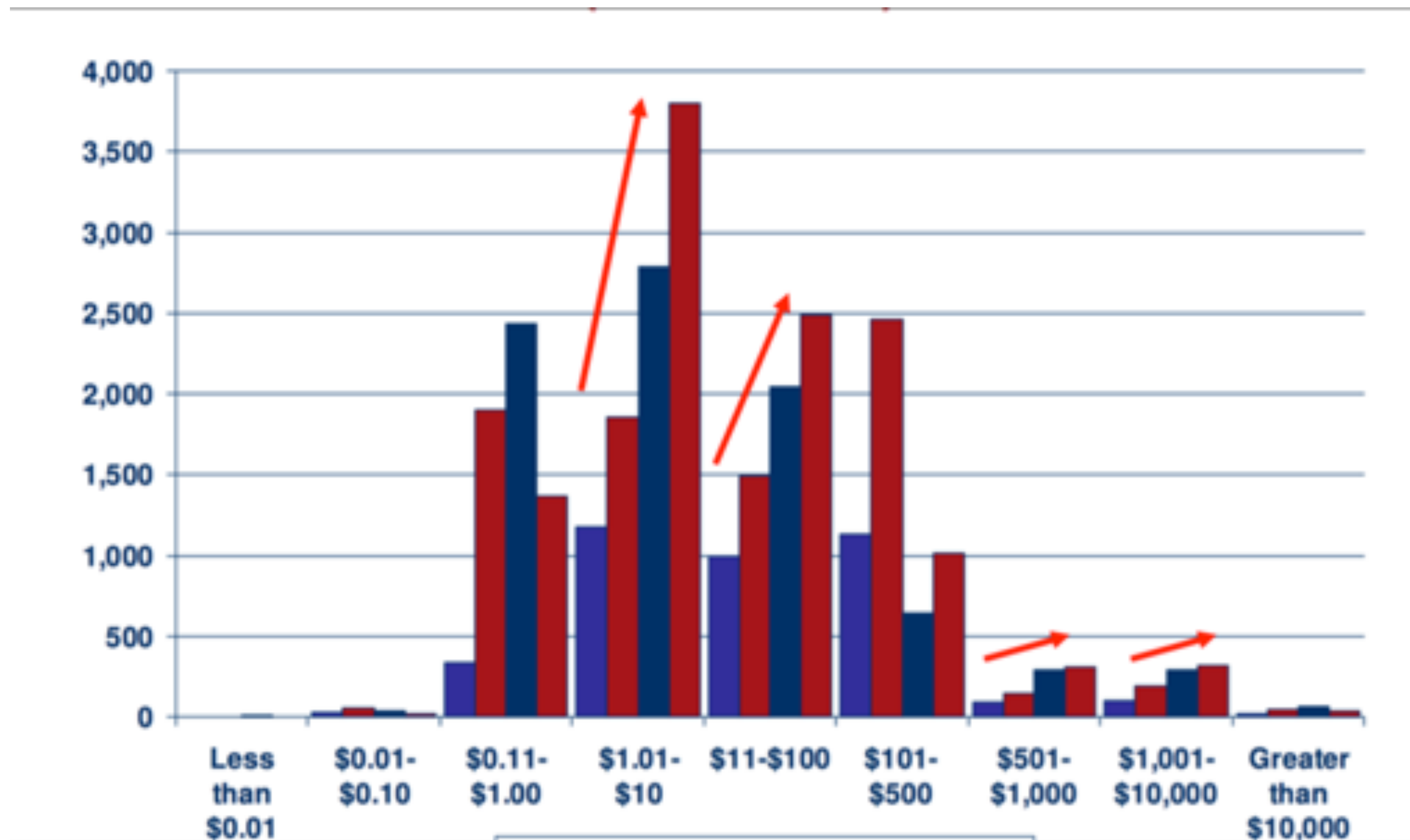
Only expensive parts are counterfeited…



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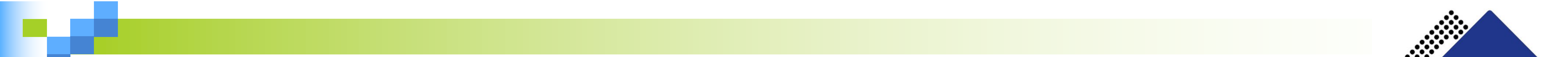
Anything wrong with these caps?

What happens when you got the wrong cap?



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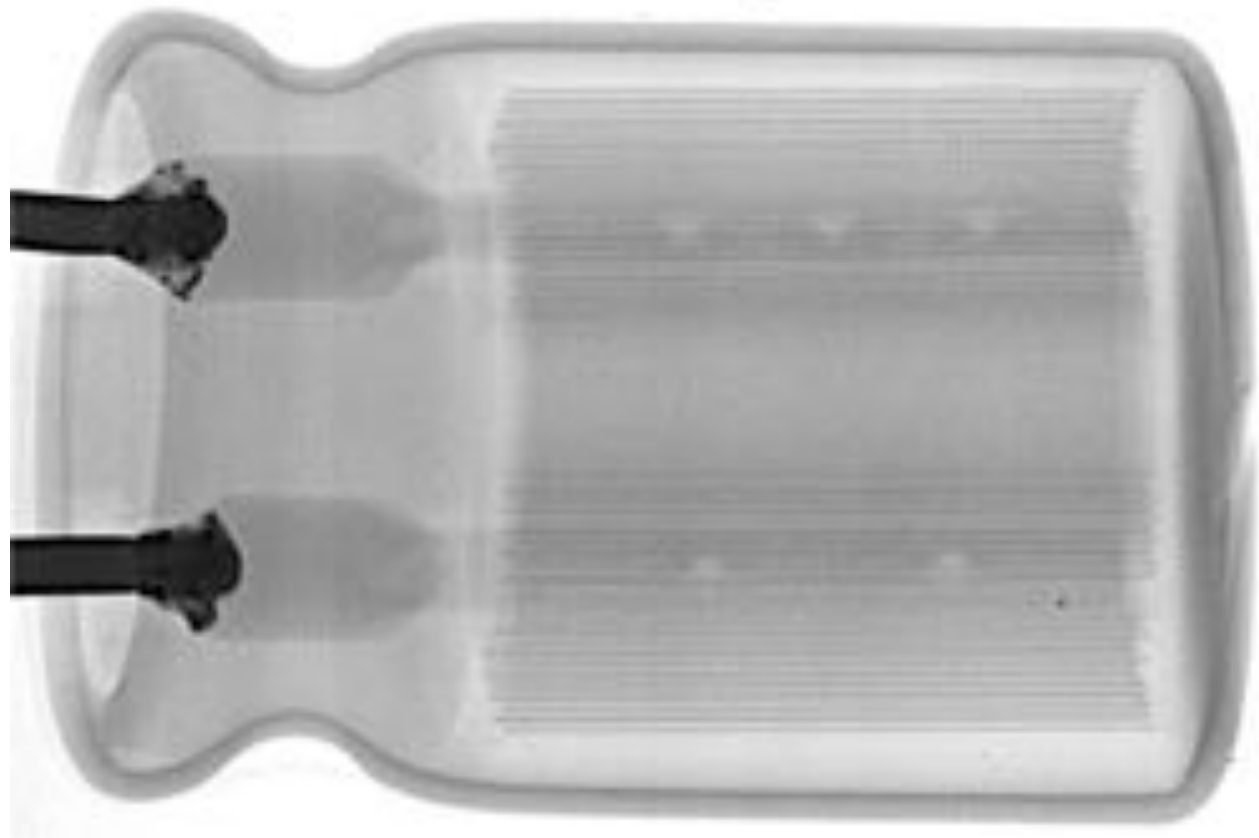

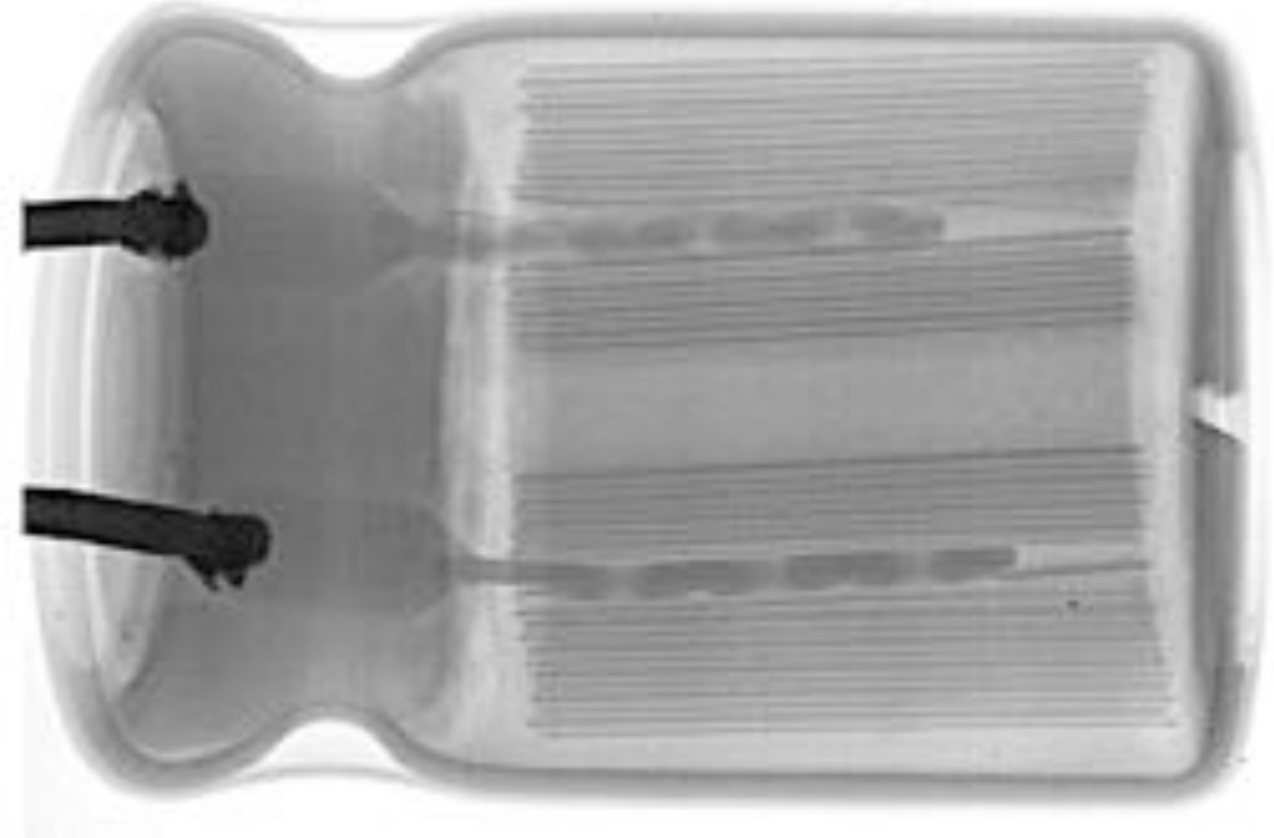

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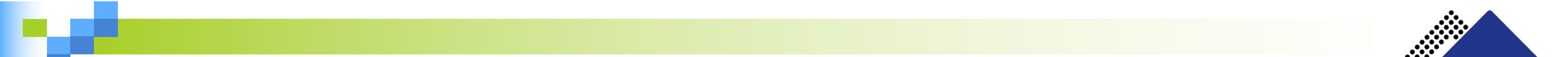
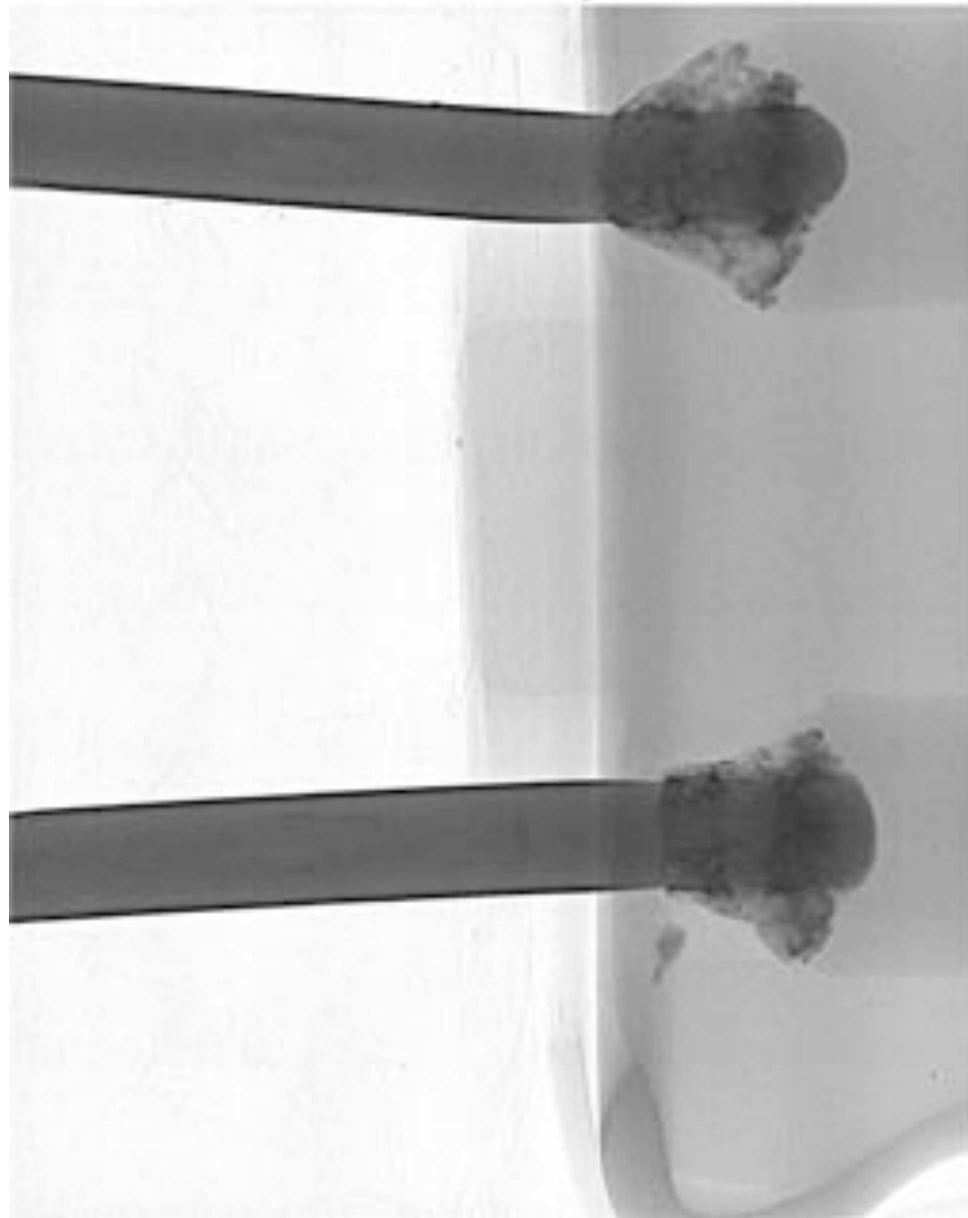
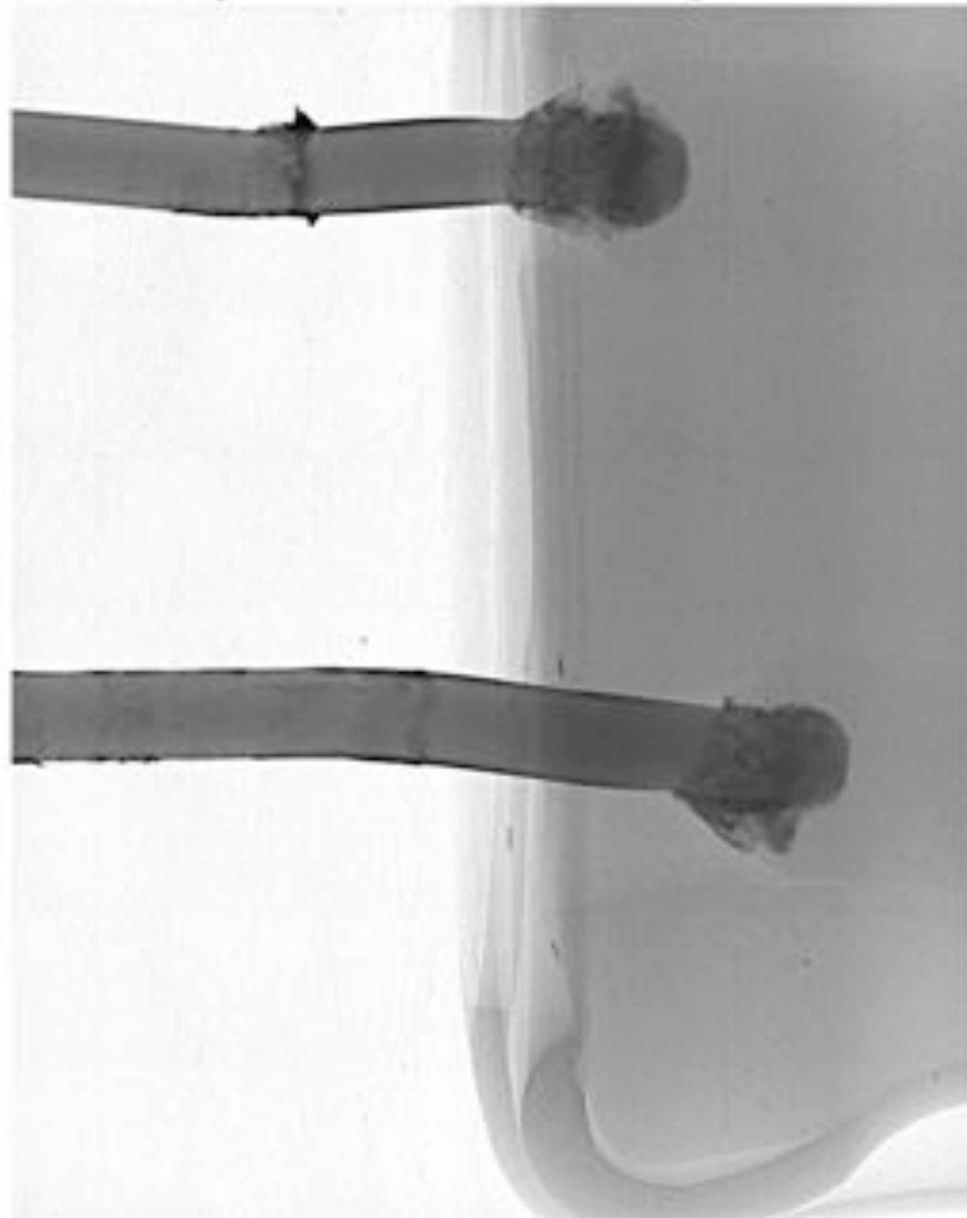


Reference Component



Suspect Counterfeit Component



Artificial Intelligence

30-second intro to artificial intelligence (AI)

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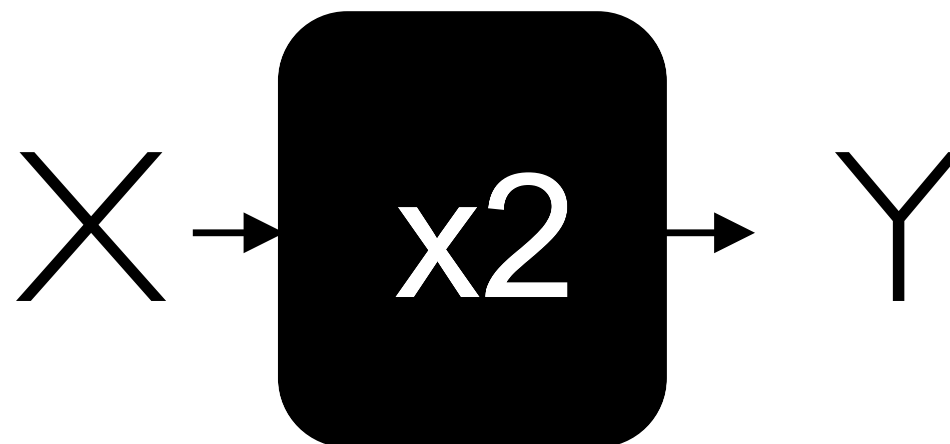

X	Y
2	4
0	0
3	6
–5	–10
10	20

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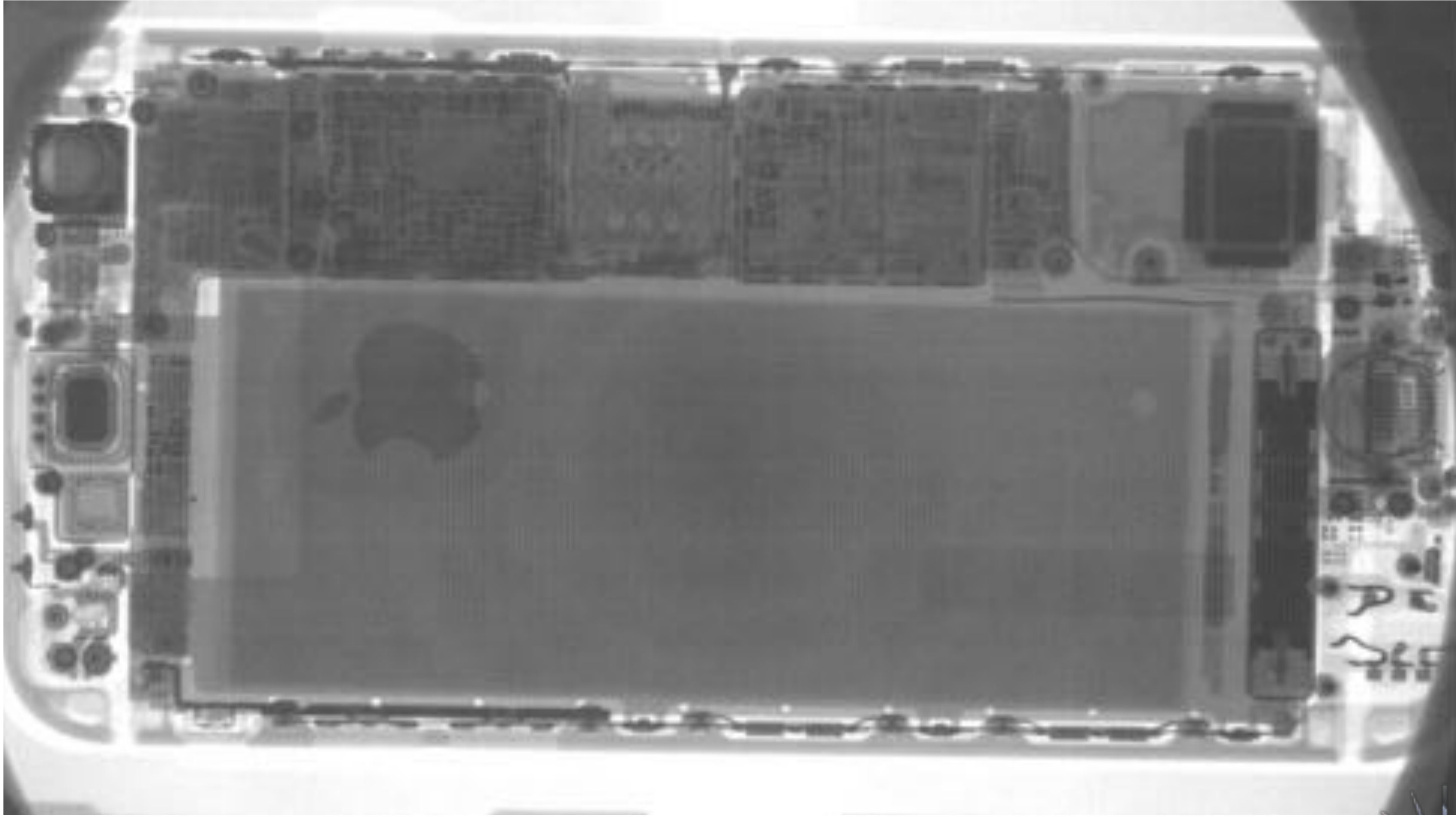

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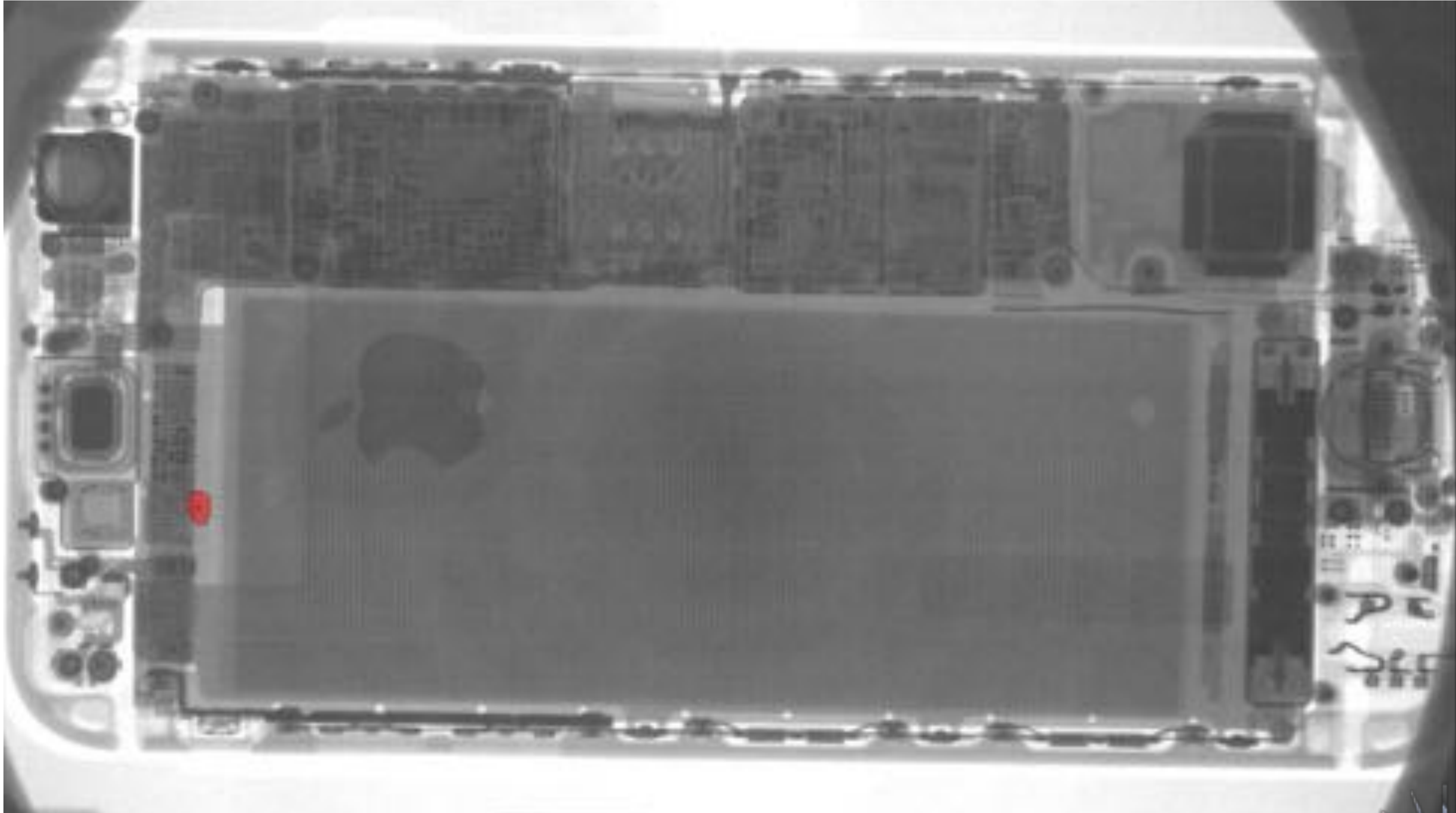

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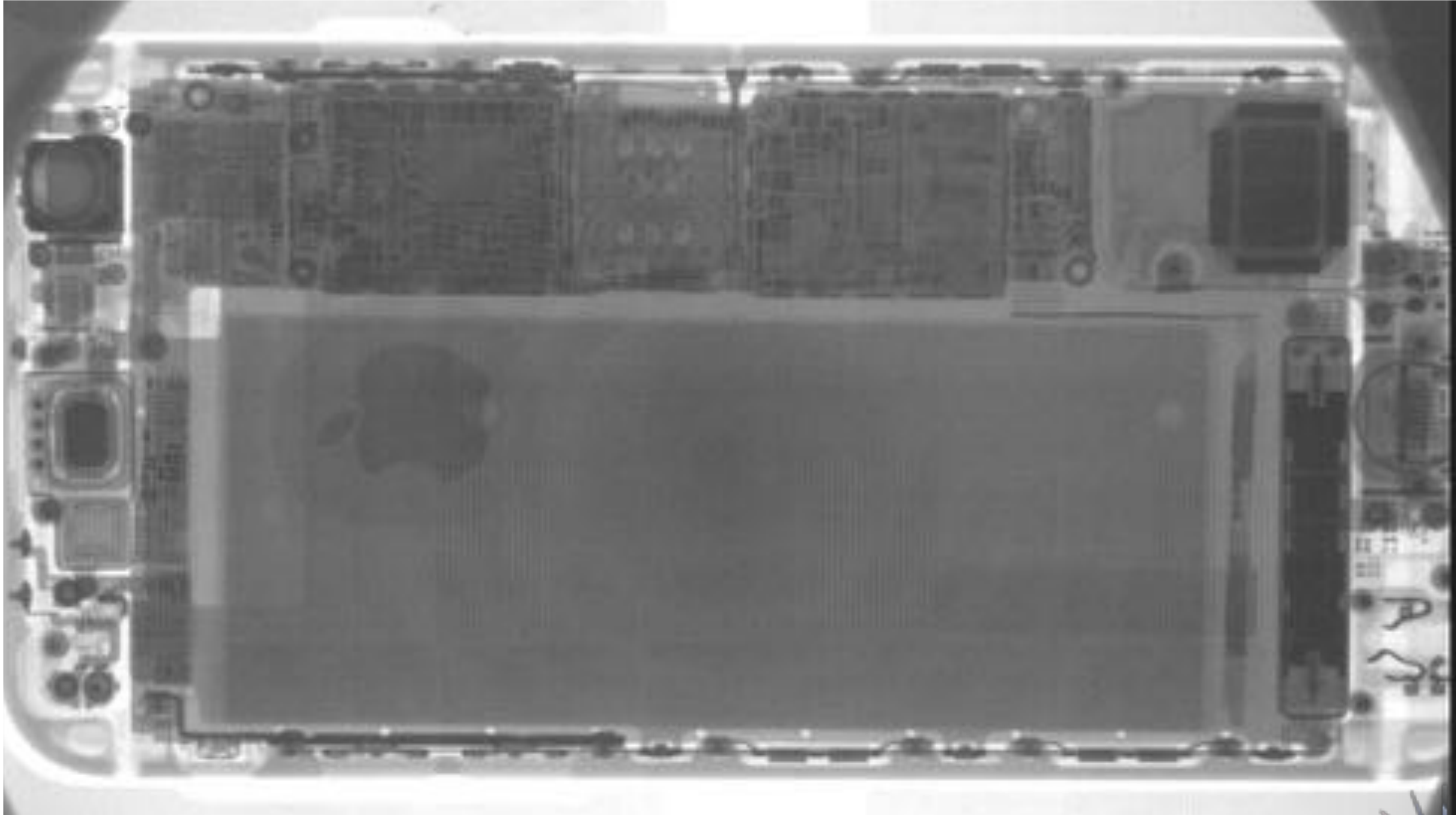

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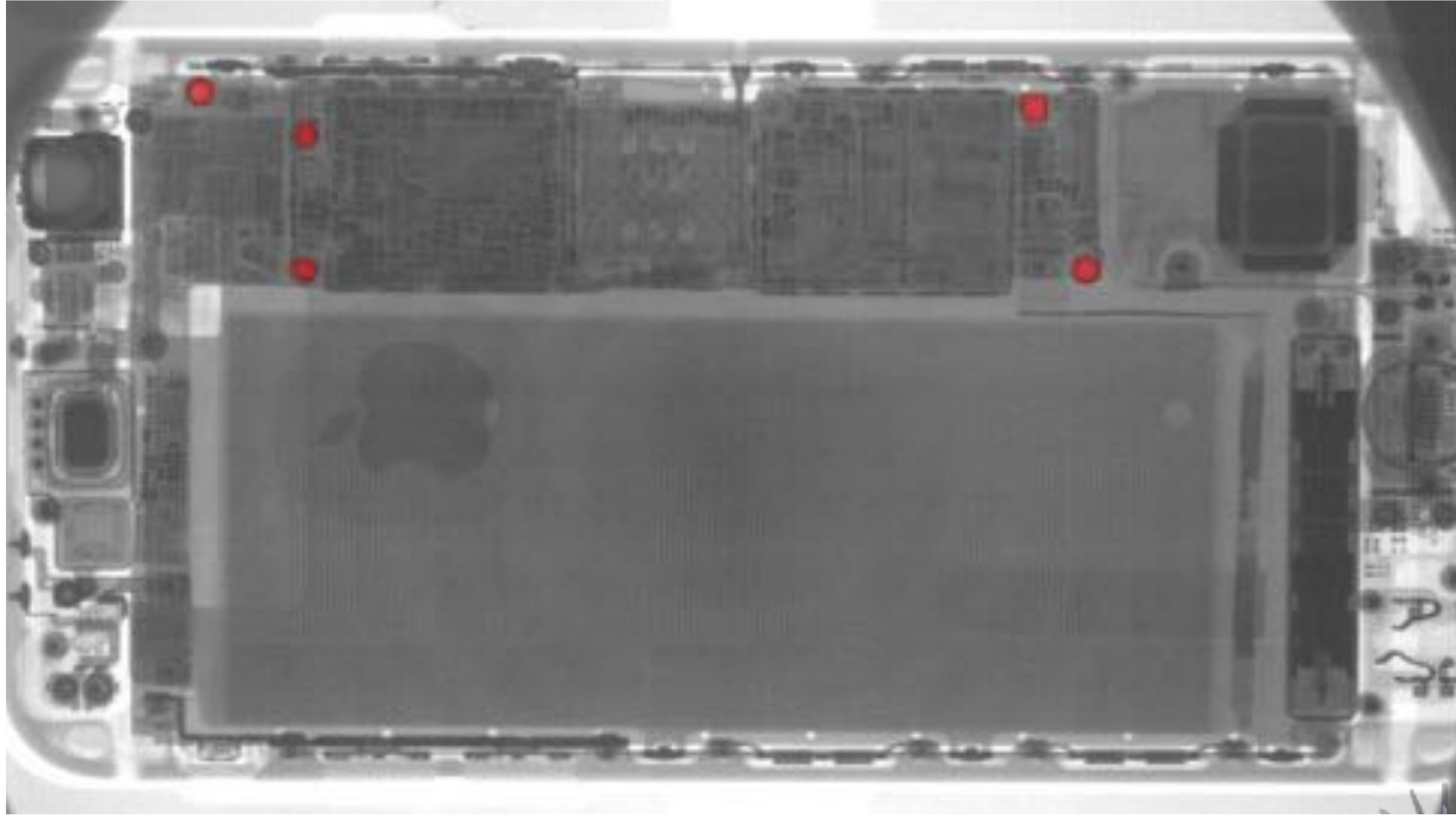

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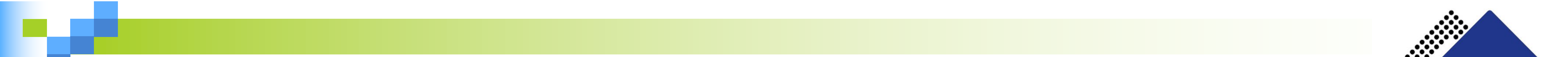

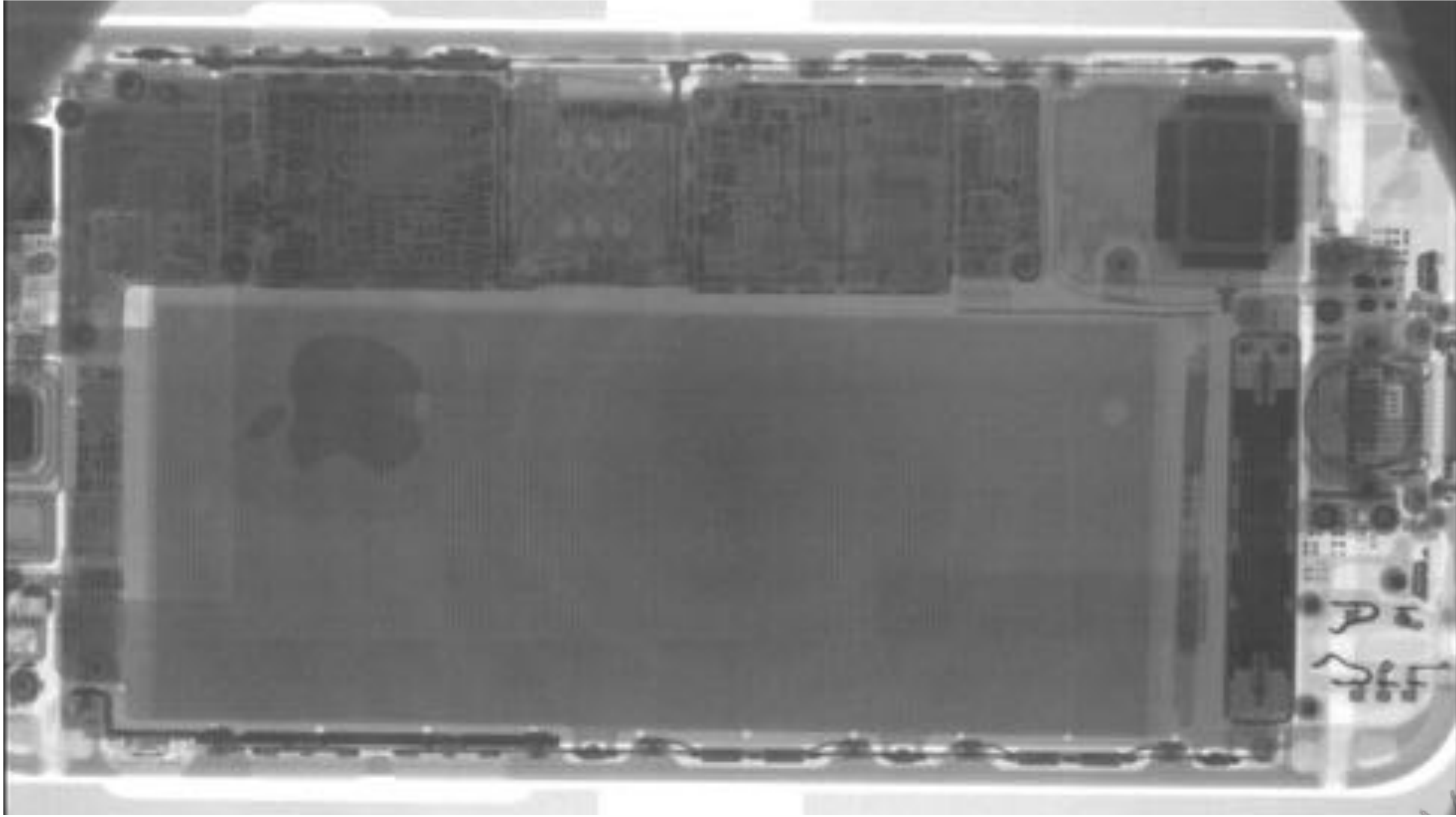

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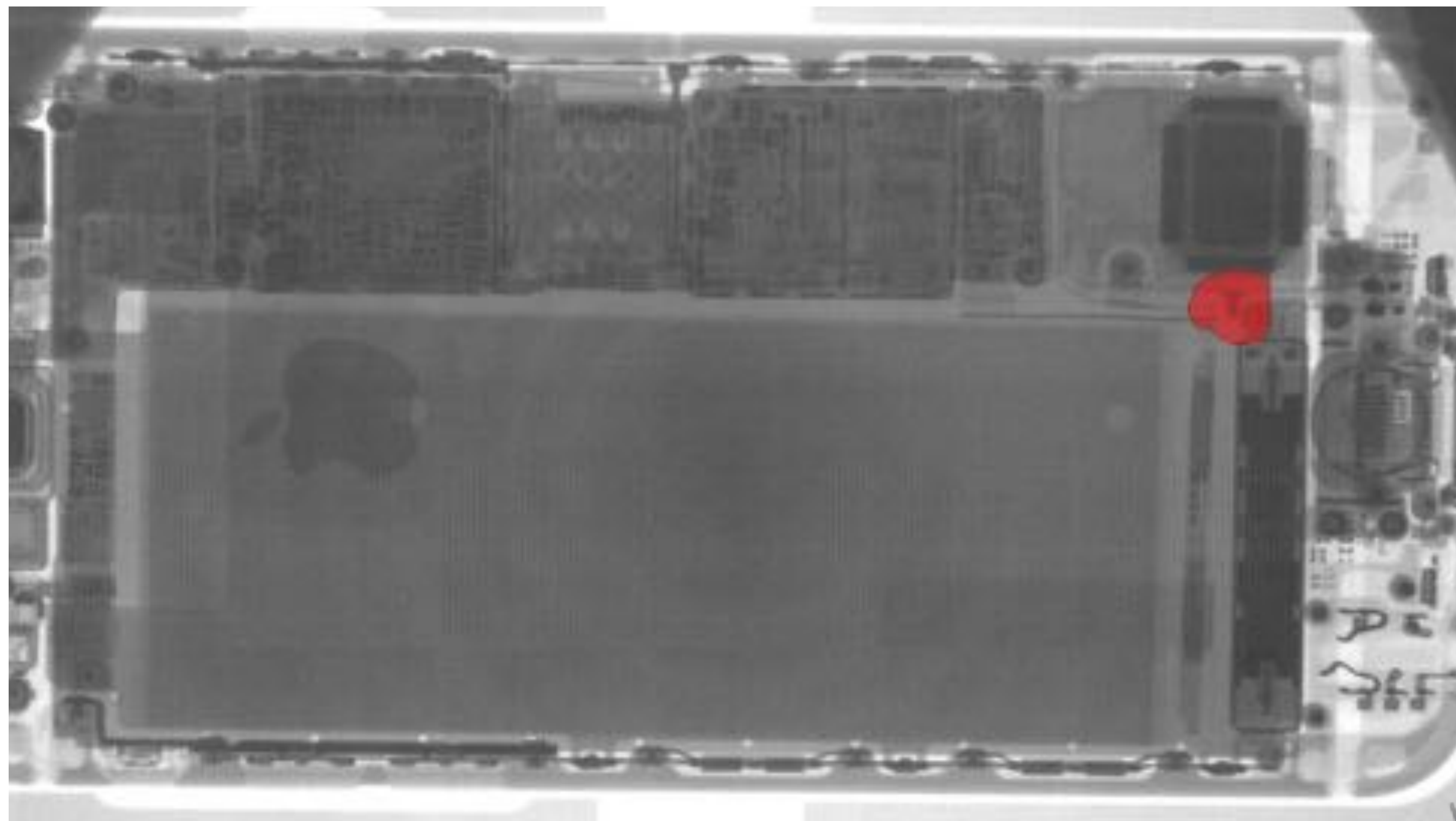

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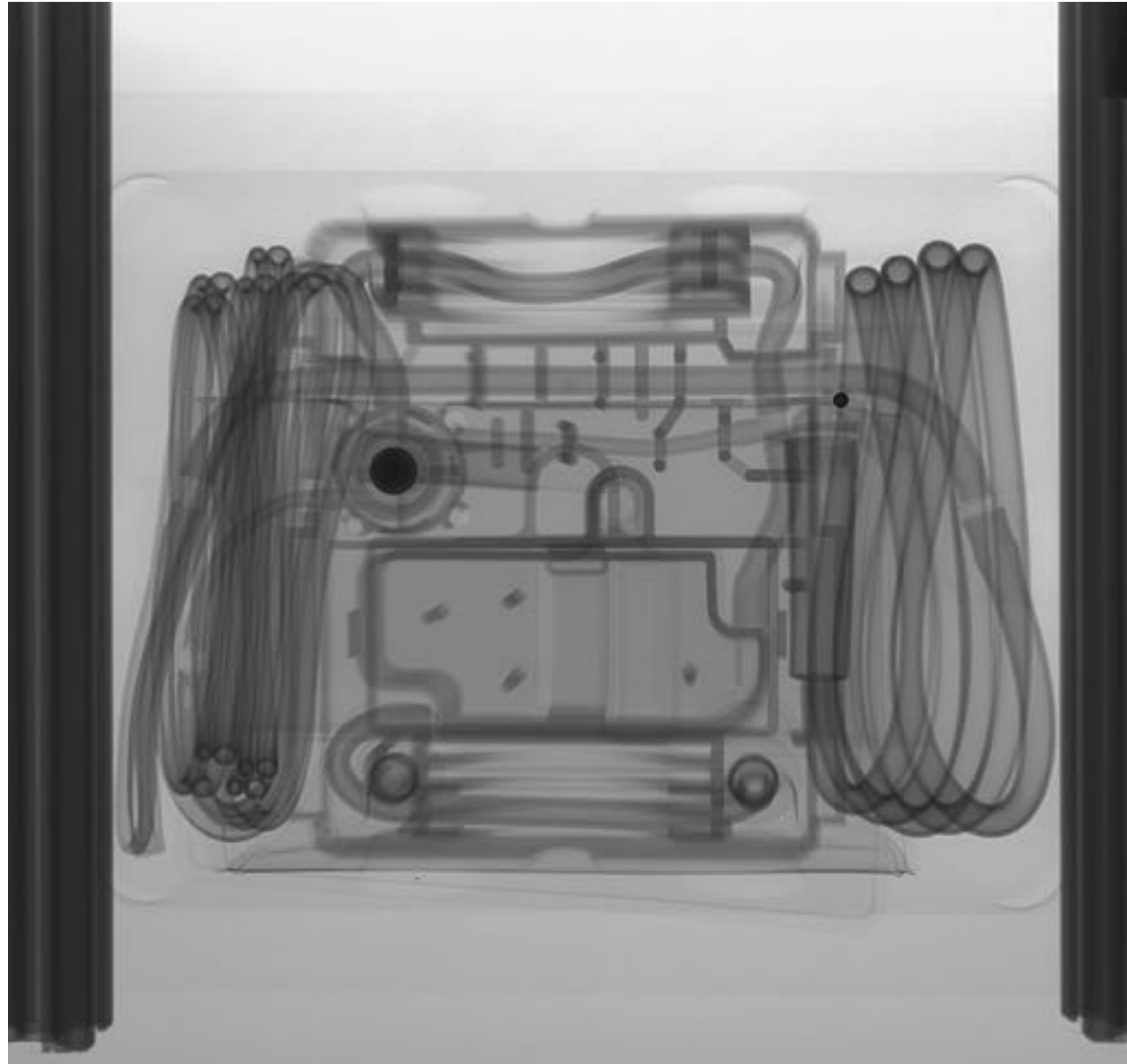

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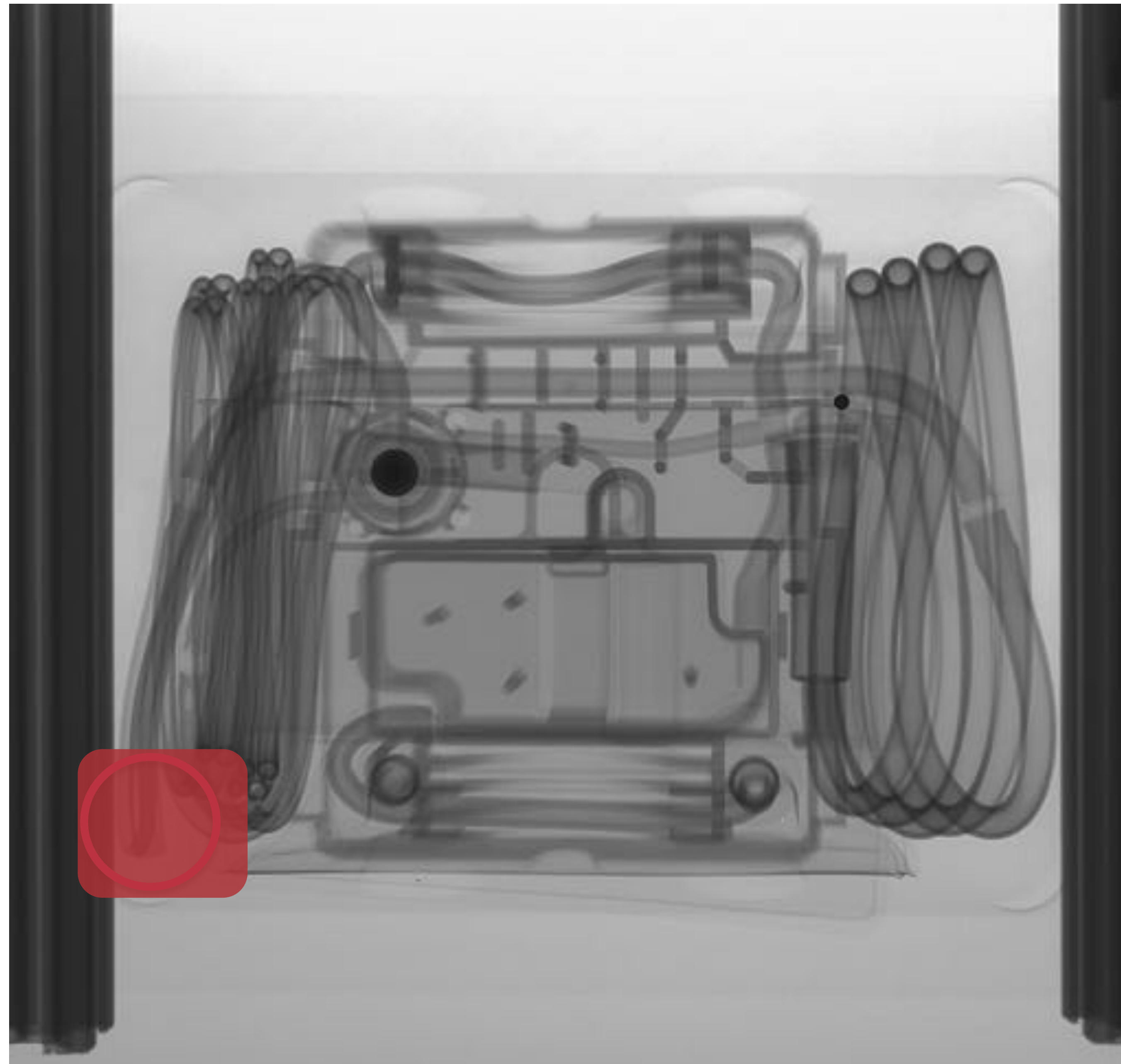

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