100% X-Ray Inspection for Automotive Reliability

SVXR

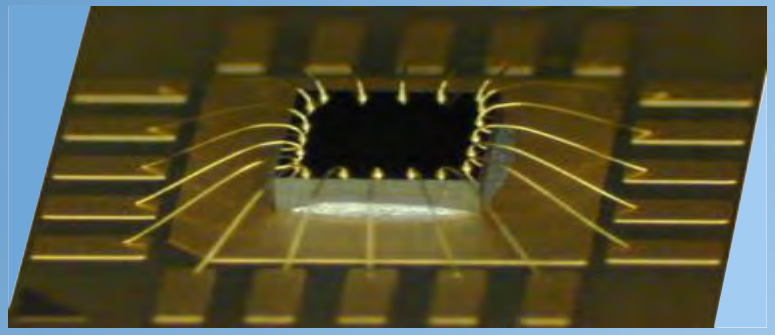
SILICON VALLEY X-RAY

Zero Defects. 100% Reliability.

Why is Reliability Important? Ask the CEO.

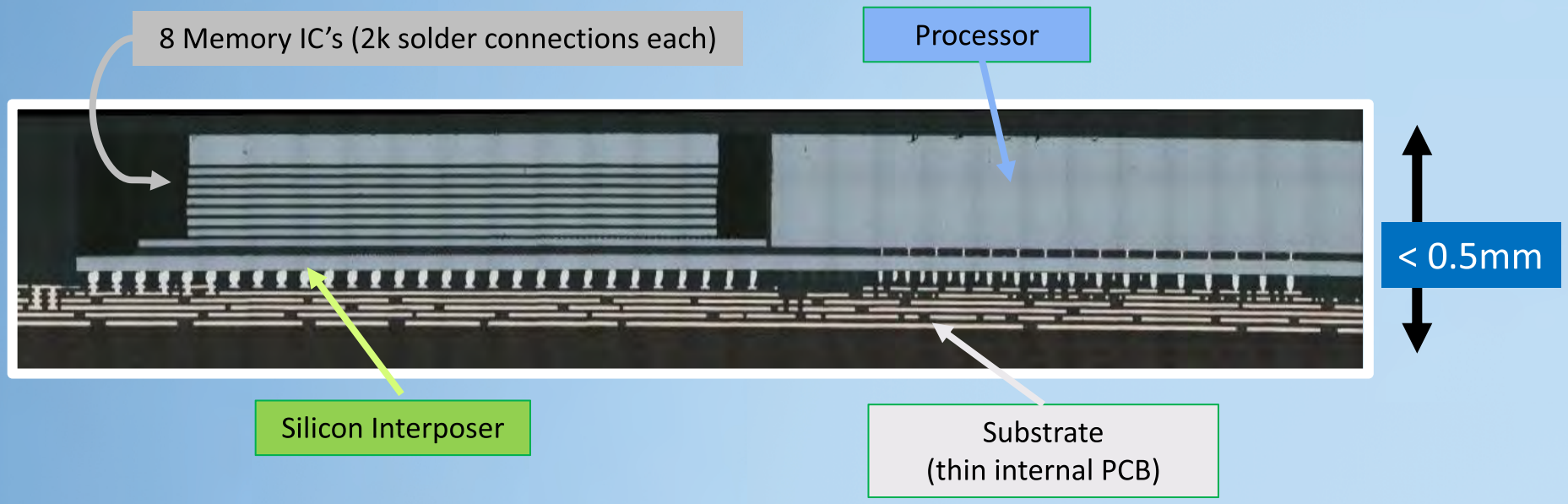
Inspecting for Reliability is More Important Now

Yesteryear: one chip, with wire bonds



Advanced IC Packaging combines many IC's and other components into a single, tiny package.

Each package can have hundreds of components, and up to 1 Million connections!



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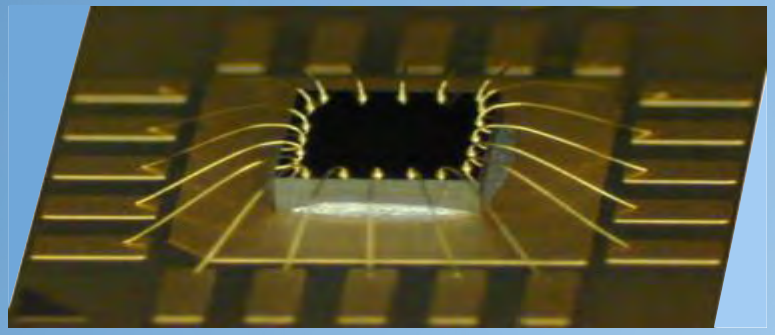

A IC's and
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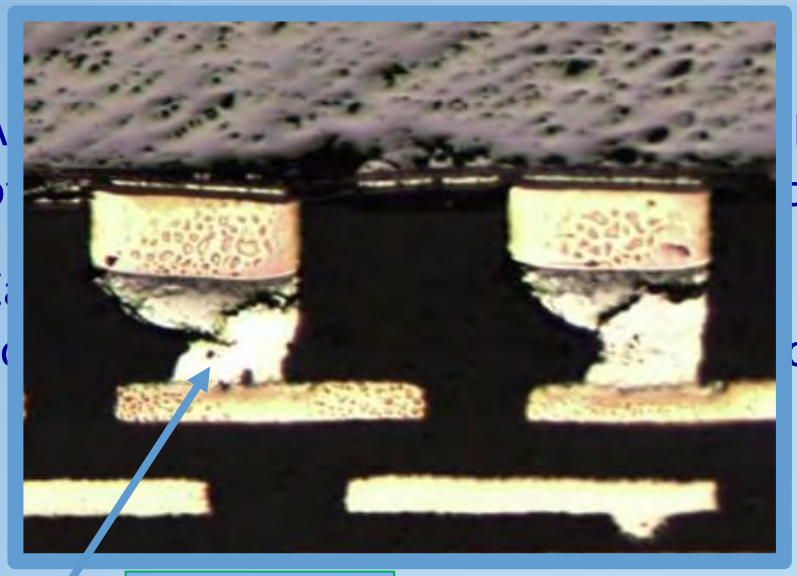
E
c ctions!



8 Memory IC's (2k solder connections each)

Processor

< 0.5mm

Silicon Interposer

Substrate
(thin internal PCB)

Electronics Reliability is a Multi-Billion Dollar Problem

- *How* can a company know that it's products will be reliable for at least 20 years of use?
- By 2025, companies will have to guarantee the reliability, each year, of over **500 Billion advanced IC packages**.
- But: Existing inspection tools can't detect the reliability problems in **advanced IC packages**.
- Therefore: There is an *unmet need* for new tools to detect ***reliability defects*** in billions of adv. IC packages.

Self-Driving Cars

Drones

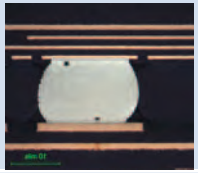
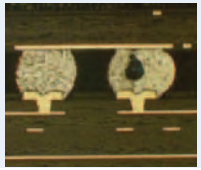
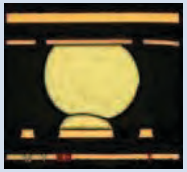
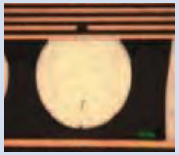
Cell Phones

Process Control Wisdom

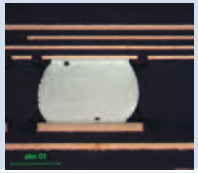
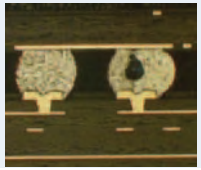
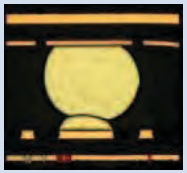
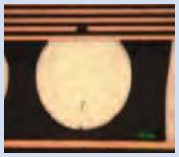
If you can't see it, you can't fix it

If you can't measure it, you can't control it

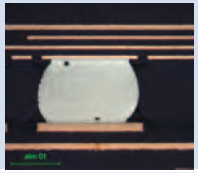
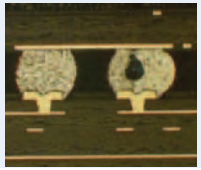
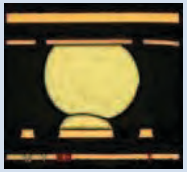
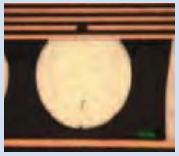
Some Types of Reliability Defects

Description	Cross-section
Good Solder Connection	
Voids **Intermittent Reliability Defect**	
Head in Pillow **Intermittent Reliability Defect**	
Non Wet **Intermittent Reliability Defect**	
Non-Contact Open	
Bridging/Short	

Electrical and Optical Testing *Can't Find Latent Defects*

Description	Cross-section	Electrical Test	Optical Inspection
Good Solder Connection		OK	Optical Inspection Can't See It
Voids **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It
Head in Pillow **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It
Non Wet **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It
Non-Contact Open		Electrical Test Can't *Always* Find It (if internal open)	Optical Inspection Can't See It
Bridging/Short		Electrical Test Can't *Always* Find It (If internal short)	Optical Inspection Can't See It

SVXR Finds ALL These Defects at High-Speed

Description	Cross-section	Electrical Test	Optical Inspection	SVXR
Good Solder Connection		OK	Optical Inspection Can't See It	OK
Voids **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It	SVXR Finds These
Head in Pillow **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It	SVXR Finds These
Non Wet **Intermittent Reliability Defect**		Electrical Test Can't Find It	Optical Inspection Can't See It	SVXR Finds These
Non-Contact Open		Electrical Test Can't *Always* Find It (if internal open)	Optical Inspection Can't See It	SVXR Finds These
Bridging/Short		Electrical Test Can't *Always* Find It (If internal short)	Optical Inspection Can't See It	SVXR Finds These

Gaps of current AOI capability from BRCM

Inspection Item	2D AOI	3D AOI	Strip level 2D Xray*
Die Chipping / Crack	Yes	Yes	?
Standing / Tombstoning	No	Yes	Yes
Misplace / Misalign	Yes	Yes	Yes
Missing	Yes	Yes	Yes
Solder Wetting (over, non)	Yes	Yes	Yes
Solder Bridge (short)	Yes	Yes	Yes
SMT / Crack	Yes	Yes	?
Extra Component	Yes	Yes	Yes
Double Component	No	Yes	Yes
Rotated Component	Yes	Yes	Yes
Die Tilt	No	Yes	?
CuP non-wet	No	No	Yes
SMT non-wet or insufficient solder	No	No	Yes
008004 SMT shorting	No	No	Yes
PCB via voids	No	No	Yes
Solder voids	No	No	Yes
Top and Bottom Assembly	2x	2x	1x
Embedded components	No	No	Yes
Stack Die	No	No	?
Die Attach coverage	No	No	Yes

*2D Xray capability estimated based on demonstration with SVXR.

High-Resolution Automated X-Ray Inspection

Fast + Automated

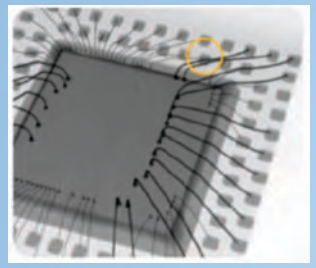
AXI: PCBA Inspection
25 um to 1 mm

HR-AXI: IC Package Inspection
1 um to 10 um

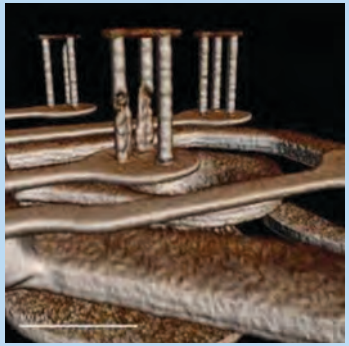
Low Resolution

High Resolution

Low-Cost Manual Inspection
50 um to 1 mm



2D / 3D Lab tools for failure analysis



Slow

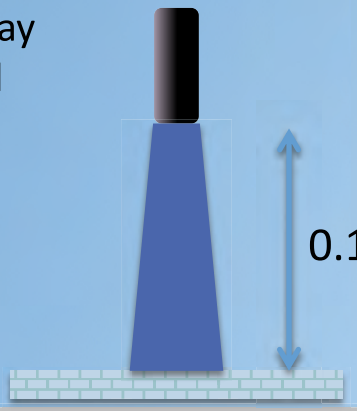
Manual X-Ray Review

SVXR's First Advantage: 100x Faster Imaging

SVXR Technology: X-Ray Sources and Detectors

SVXR's Proprietary X-Ray Source: 1000x more power (1000 watts)

SVXR's unique x-ray system is covered by multiple US Patents.

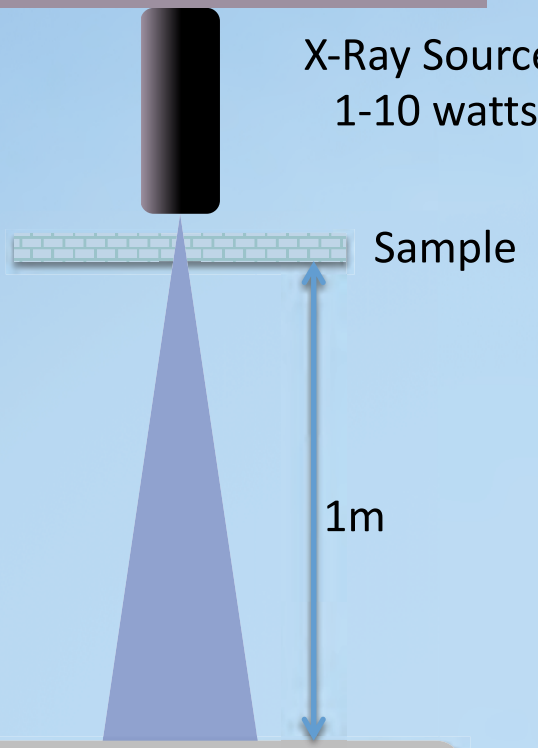


SVXR's Proprietary Detector:
30 mega-pixel, 65,000 gray-levels

SVXR'S system is 100x faster, and has higher sensitivity (SNR).

Yet: Has lower dose / part than conventional x-ray systems

Traditional X-Ray System: Resolution Limits Speed



Typical X-Ray Detector:
2 mega-pixel, 256 gray-levels

SVXR
SILICON VALLEY X-RAY

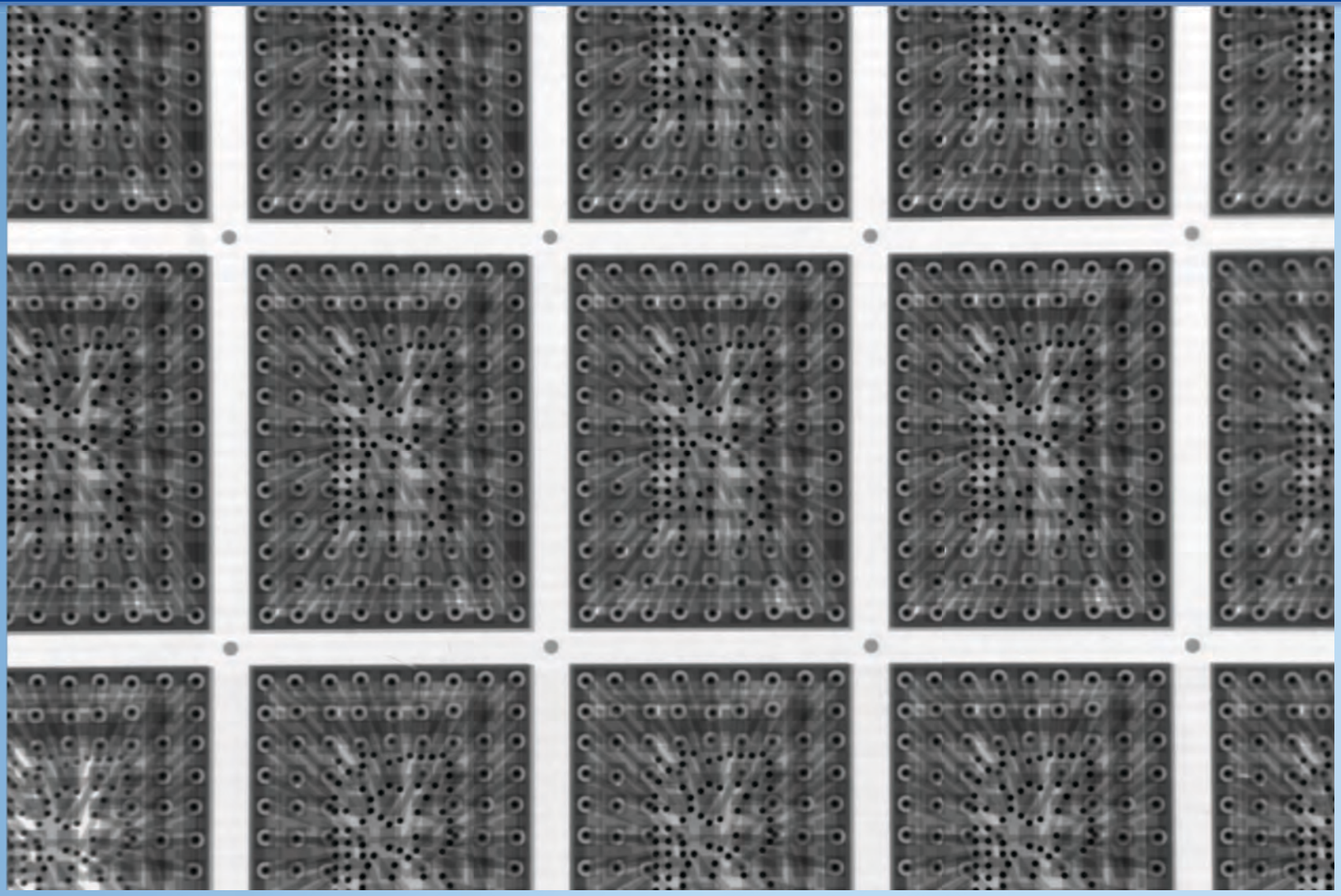
SVXR advantage: high-speed and high-resolution capability

Specification	Vitrox	Dage	SVXR
Lateral Resolution	25 – 100 micron	4 um	2.5 um
Beam Power	50 watts	10 watts	1000 watts
Sensor Size	2 MPixels	4 MP	30 MP
Throughput	Can't meet Resolution	26 units/hour	5000 units/hour

SVXR's unique x-ray imaging technology:

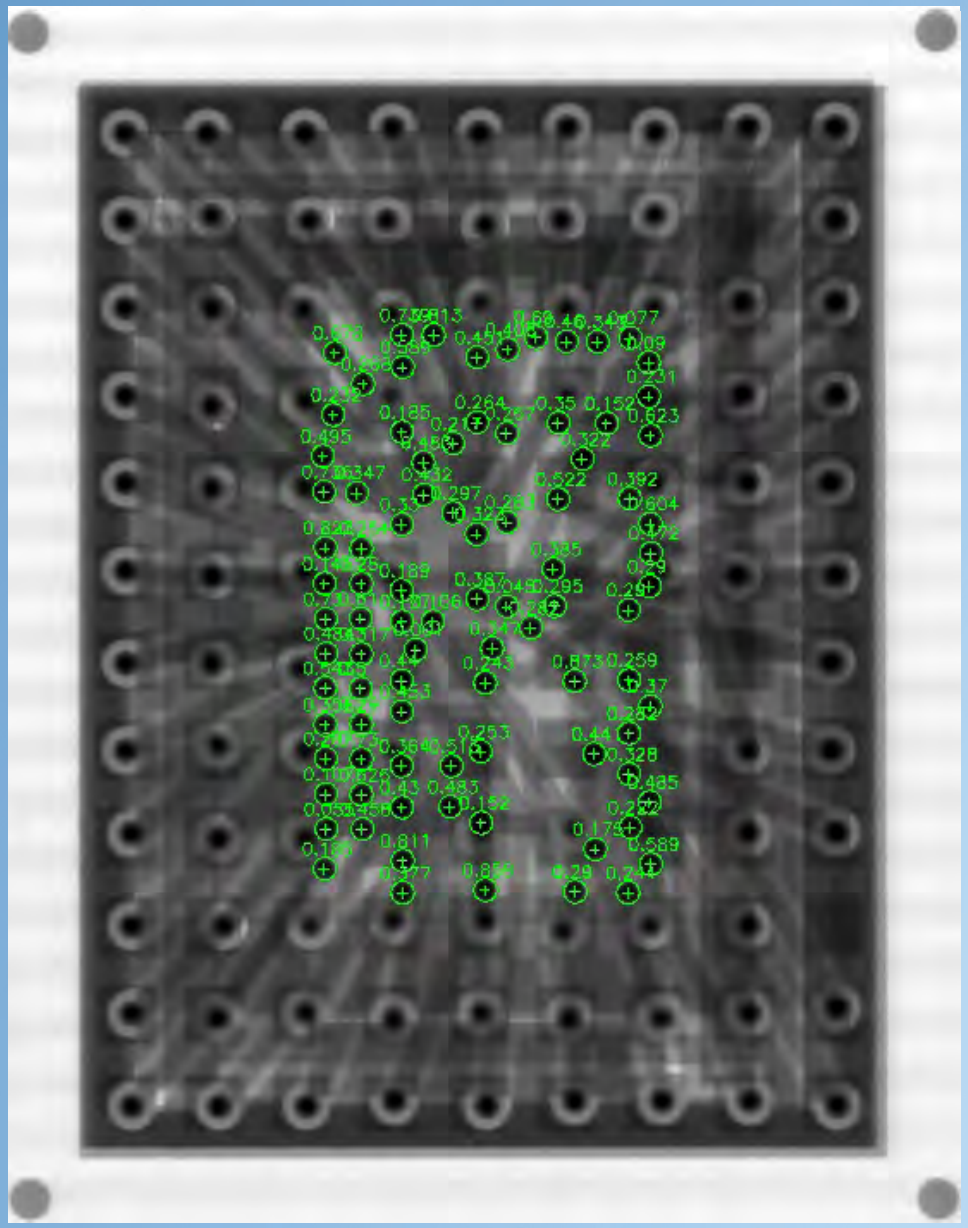
- Developed specifically for Advanced IC Packaging
- Covered by US and foreign patents
- 100x faster than comparable systems
- Uses a new x-ray source technology developed by SVXR
- Uses a new x-ray detector technology developed and built by SVXR
- Uses custom AI algorithms for defect detection and process control
- Fully-automated Load/Unload for Wafers, Boats, Strips, Panels

100 SiP Units (non-wet test vehicle)



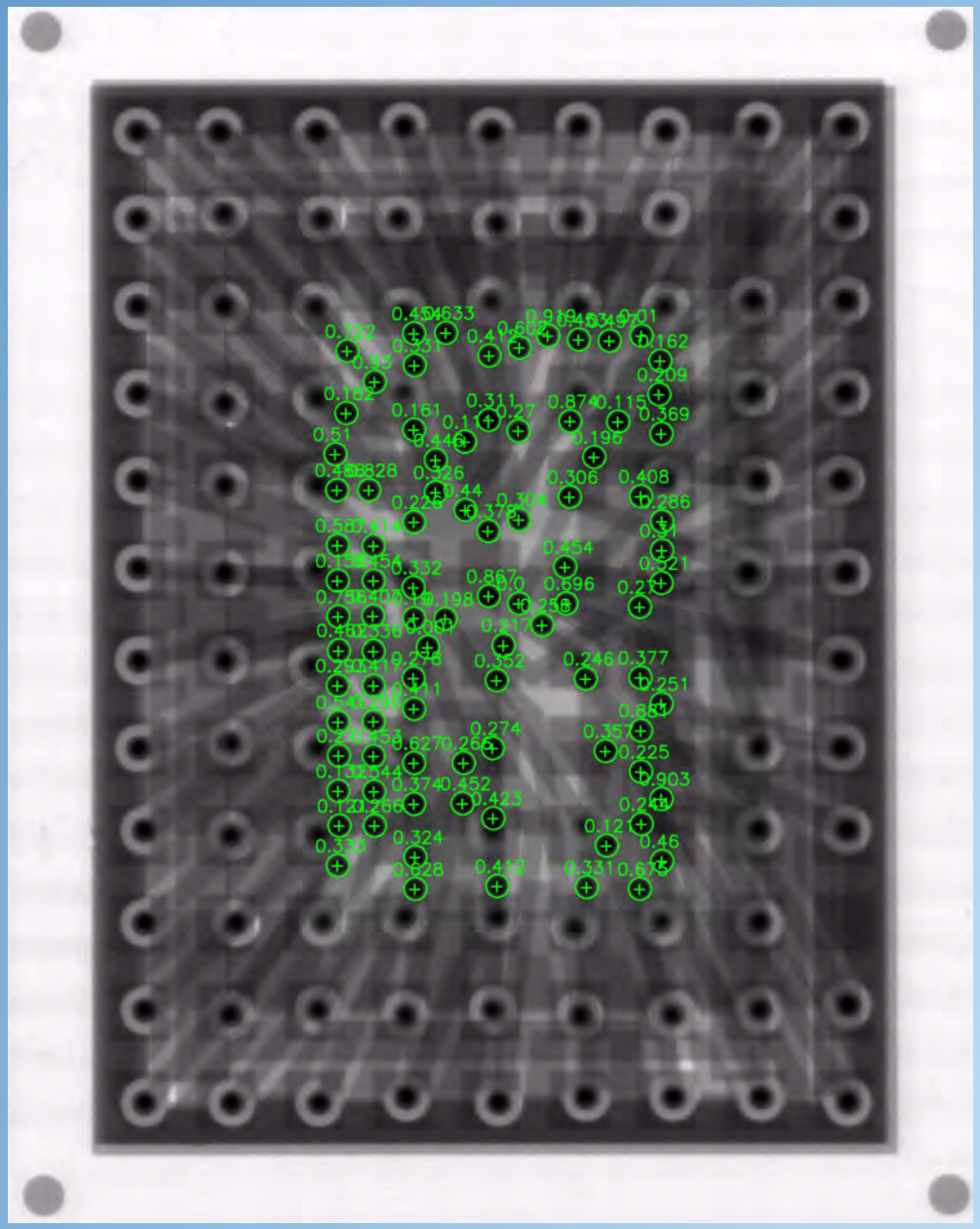
- 12mm x 18mm FOV @ 2.8 um resolution (30 MP)
- Throughput > 3000 mm^2/min = 50 mm^2/second (over 5k units/hour)

PDTV



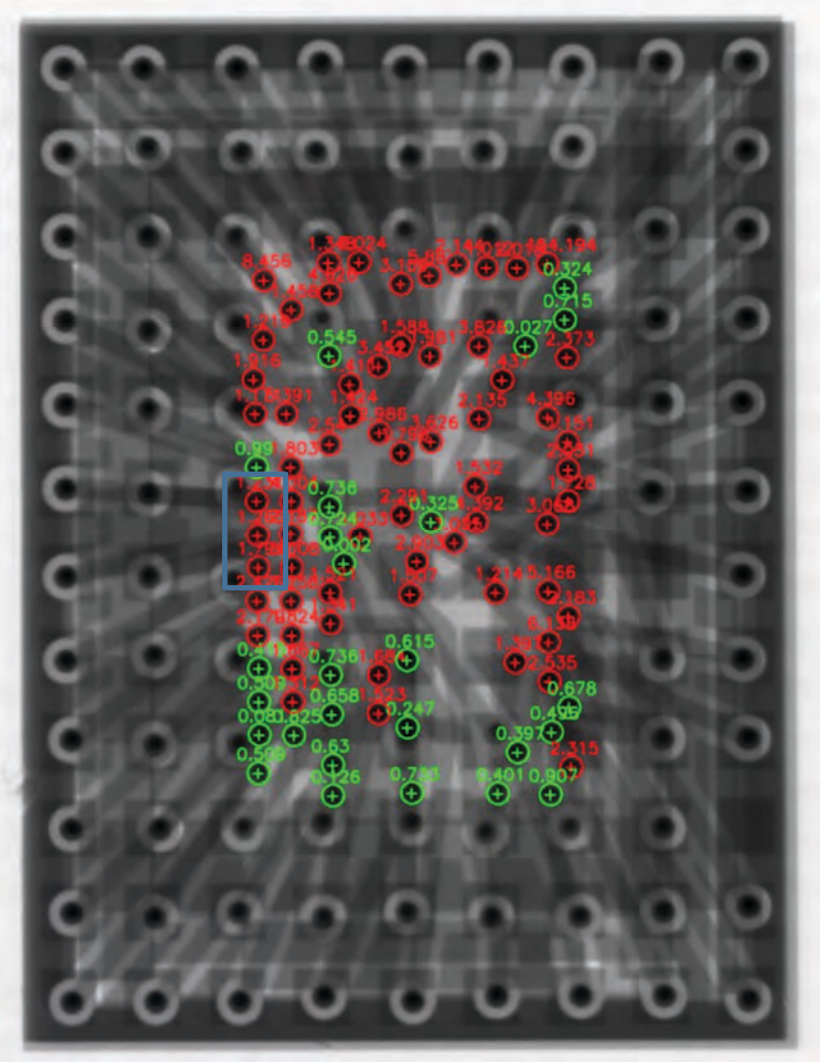
- LNA package contains 90 solder joints for inspection.
- Solder joints automatically identified in each package.
- Metrics calculated for each solder joint. Score indicates quality of joint.

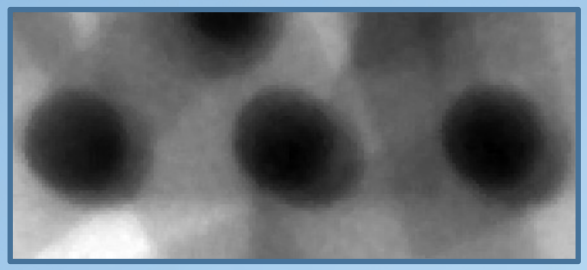
PDTV



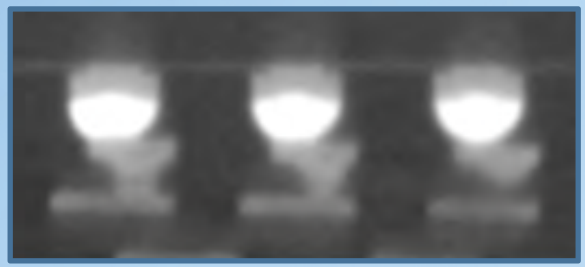
- Each package inspected, metrics computed for each joint.
- Pins with low metrics (green) are passed.
- Pins with high metrics are flagged as outliers.

PDTV



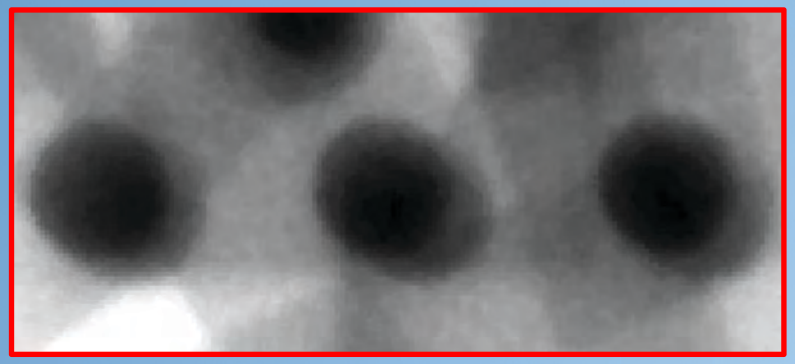


Top down 2D view (SVXR)

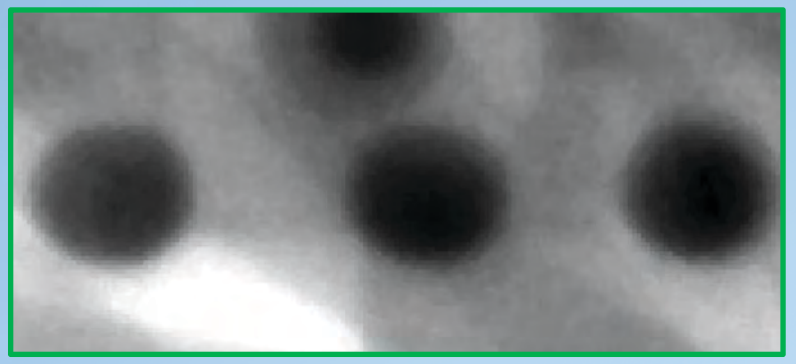


High resolution 3D X-Ray cross section verifies defective joints.

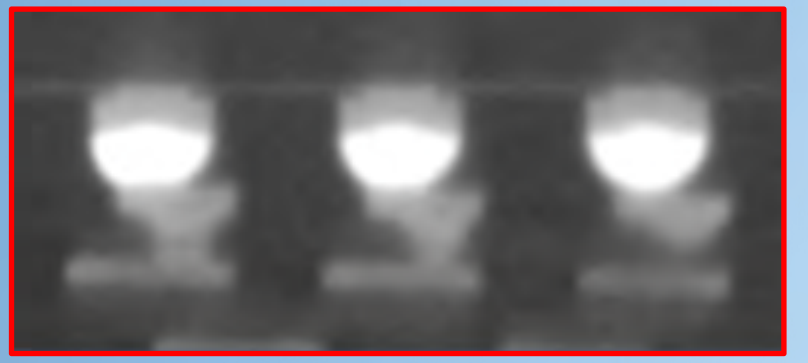
SVXR Finds Non-Wet Defects with HR-AXI



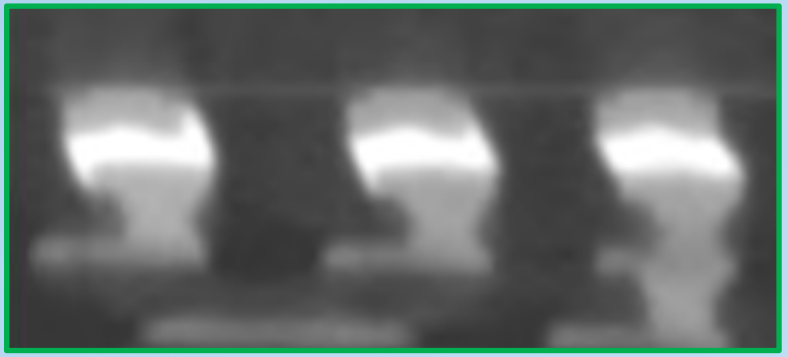
SVXR Image showing pins flagged by ML



SVXR Image showing pins passed by ML

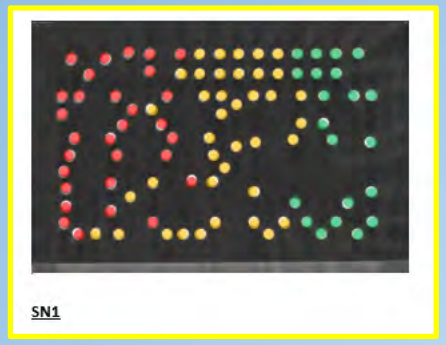


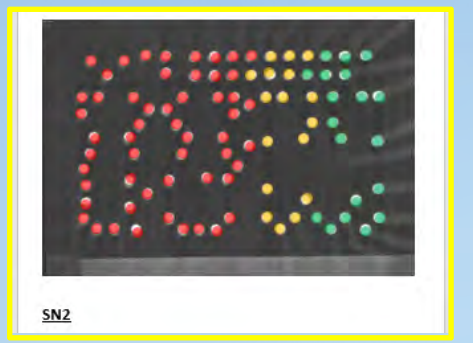
High resolution 3D X-Ray cross section verifies nonwet joints on above joints.



High resolution 3D X-Ray cross section showing good solder connection.

Non-Wet Defect Detection





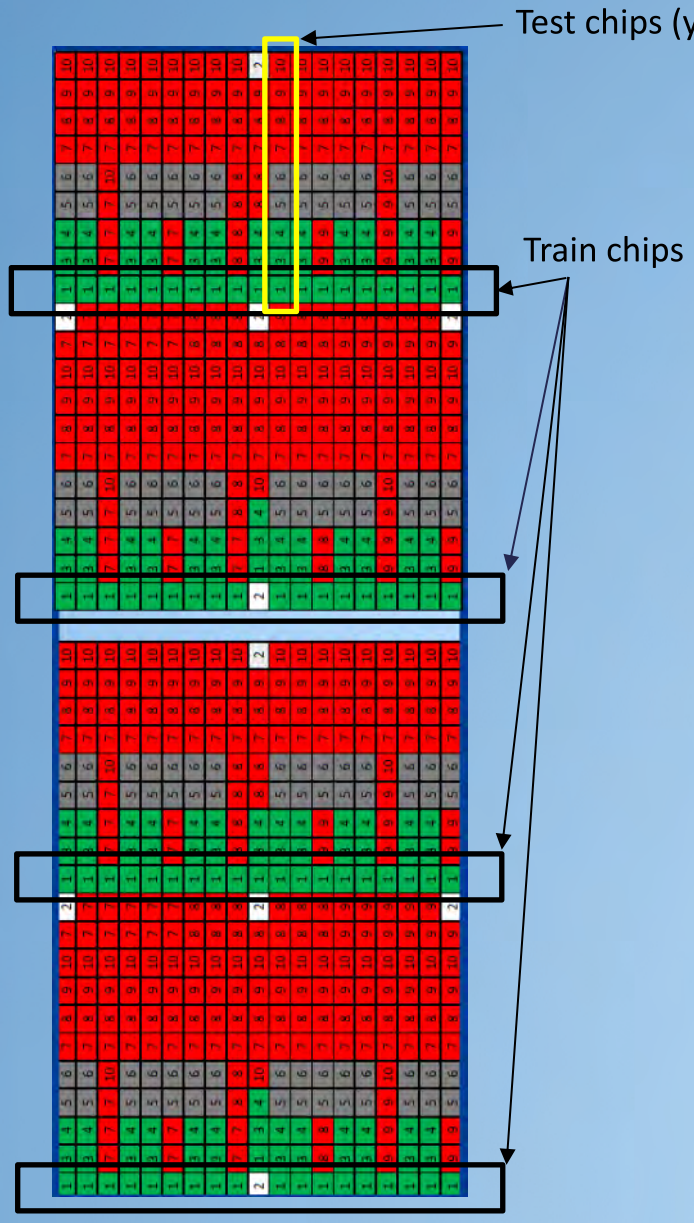
100% Nonwet

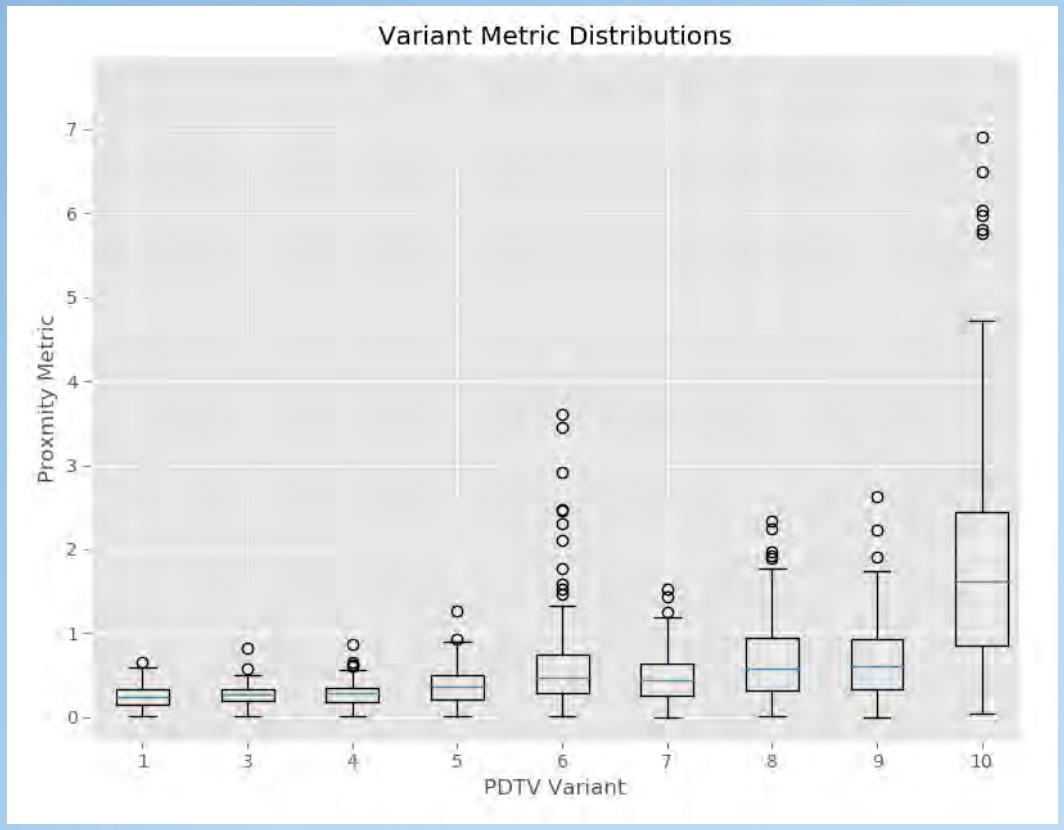
Partial Nonwet

Good Joint

SVXR selected 3 packages for review, with many outliers detected by ML algorithm. Samples sent for 3DCT review. Results show many nonwet and partial nonwet joints in these packages. Top left shows high resolution cross sections of joints.

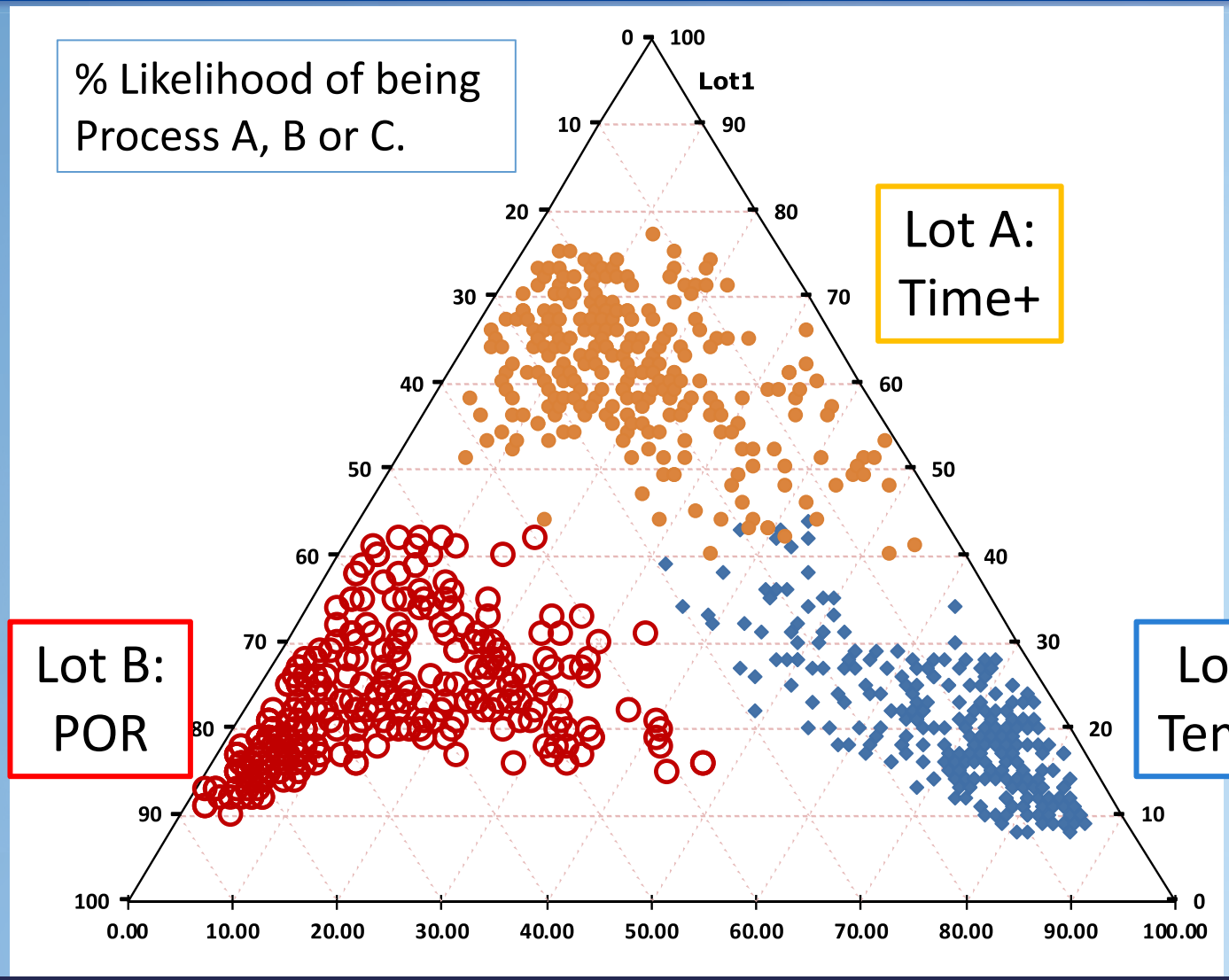
Outlier Analysis





ML analysis of 10 chips (highlighted in yellow). Box plots summarize distribution of proximity metric scores for each pin.

SVXR Accurately Detects Small Process Changes



These process changes *cannot* be detected electrically

These process changes *Do Affect Reliability!*

SVXR is the *FIRST* and *ONLY* System for 100% Inline Inspection

- 100% Inline inspection for *all* defects, including reliability defects
- Complete Process Control and Monitoring to catch excursions *fast*
- SVXR's unique technology has a *unique technical advantage*
  - **Unique High-speed, high-sensitivity x-ray imaging that's 100x faster**
  - **Unique AI-Based Image Processing for Process Control and Defect Detection**
- **SVXR's** tools will become the universal standard to guarantee reliability in Advanced IC Packages.

SVXR Protects You from the Walking Wounded

latent failure (zombie defects) = walking wounded