Measurement of Buried Features in Packages Using 3D X-ray

Thom Gregorich, Director
ZEISS Process Control Solutions

April 10, 2019

Advanced Packaging: Game Changer for Semiconductor Revolution

YOLE DEVELOPPEMENT April 4, 2019 Blogs, From Different Dimensions

0 Comments

Heterogeneous integration paving the way beyond silicon scaling limits

Reflections on IWLPC 2017

By Louis Burgyan, LTEC Corporation

As in prior years, the in-depth presentations at this year's IWLPC, covering a broad array of the industry's critical challenges, did not disappoint. A series of keynote presentations and papers included a couple of major announcements that will be discussed below. Of special note, several keynote speakers

Richard (Kwang Wook) B
Samsung Electro-Mecha

FOPLP at the verge of volume production

Over the years, the industry became accustomed to Apple being
giving forward-lookin
and deep analysis ca
All the more reason t
Planning Team at San

Chip Industry Maps Heterogeneous Integration

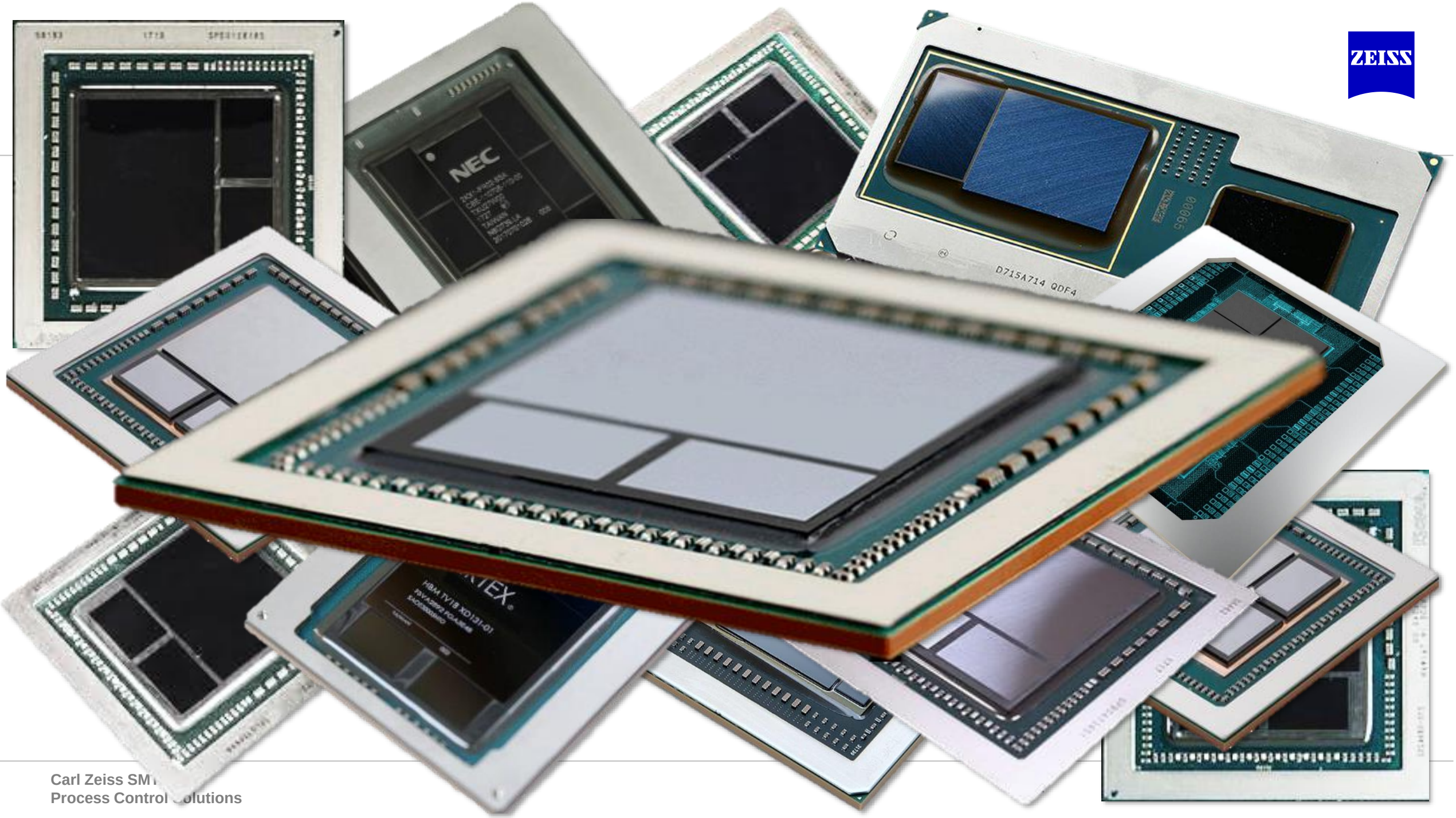
Nicky Lu talks about 'ubiquitous intelligence'

rd global domination by
way, we've seen that future,
ality, and autonomous vehic

Advanced packaging to generate nearly US$3 billion in revenues in 2019, says TSMC chairman

Julian Ho, Taipei; Willis Ke, DIGITIMES *Tuesday 26 March 2019* 0

Pure-play foundry TSMC remains aggressive in expanding its advanced packaging business, which will generate nearly US$3 billion in revenues this year, according to company chairman Mark Liu.


NEC
D715A714 QDF4


Buried Costs!
NEC
D715A714 QDF4
intel Nervana
XILINX
VIRTEX

Buried Costs are not Directly Controllable

Buried costs do not include:

- The bill of materials
- Direct labor
- Other directly controllable costs

Buried package costs include:

- Process development costs incurred during the bring-up of a product
- The cost of line scrap and field failures when products do not meet performance requirements
- The cost of lost sales when products are not able to ship on-time

There Might be a Few Gaps in Packaging Technology...

Evolution of Semiconductor Inspection and Metrology

Wafer Fab

Package Asy

1970's~1980's | 1980's~1990's | 1990's~2000's | 2000's~2010's

Evolution of Semiconductor Inspection and Metrology

Wafer Fab

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1970's~1980's | 1980's~1990's | 1990's~2000's | 2000's~2010's

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Evolution of Semiconductor Inspection and Metrology

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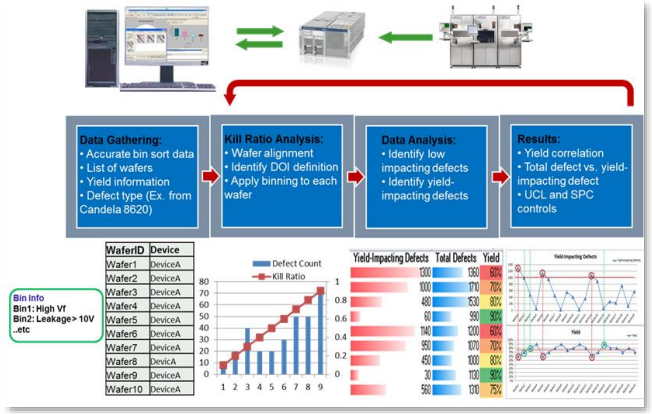
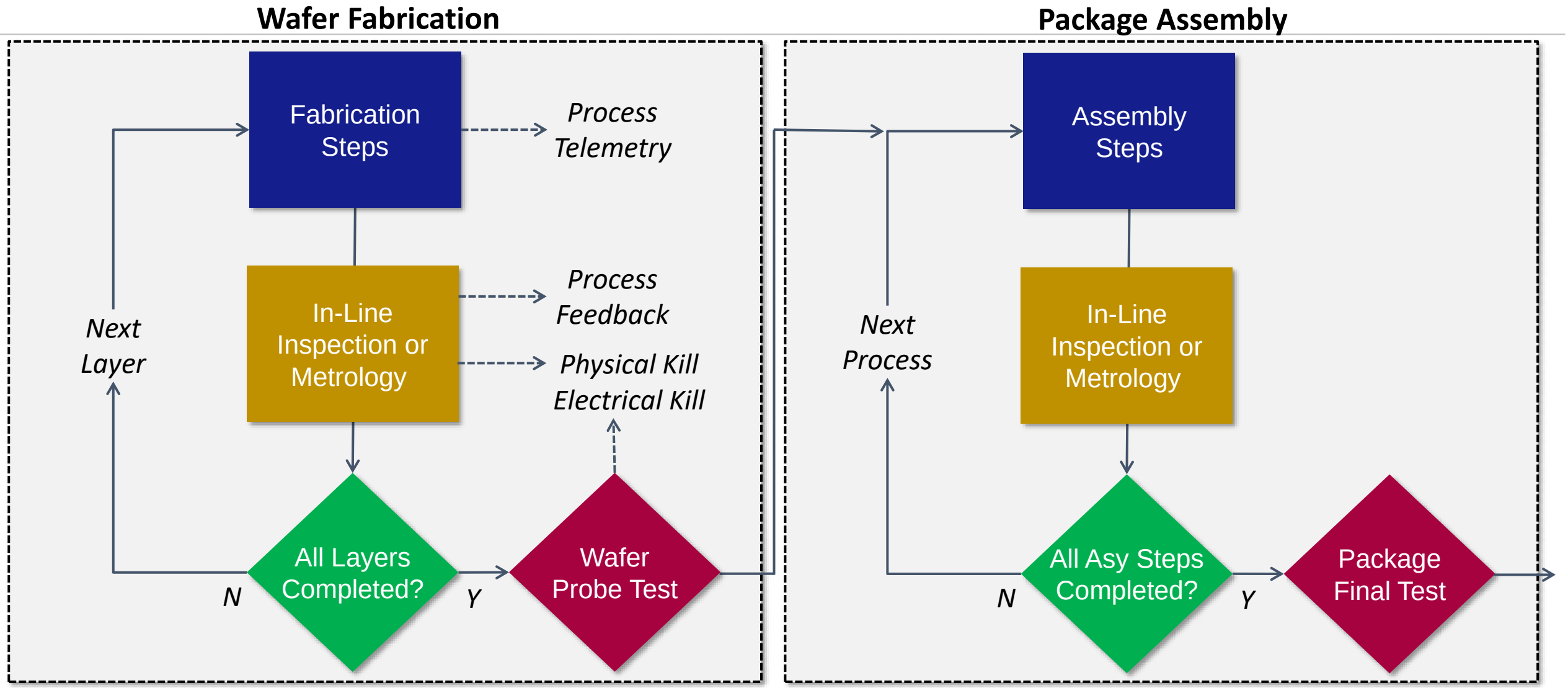


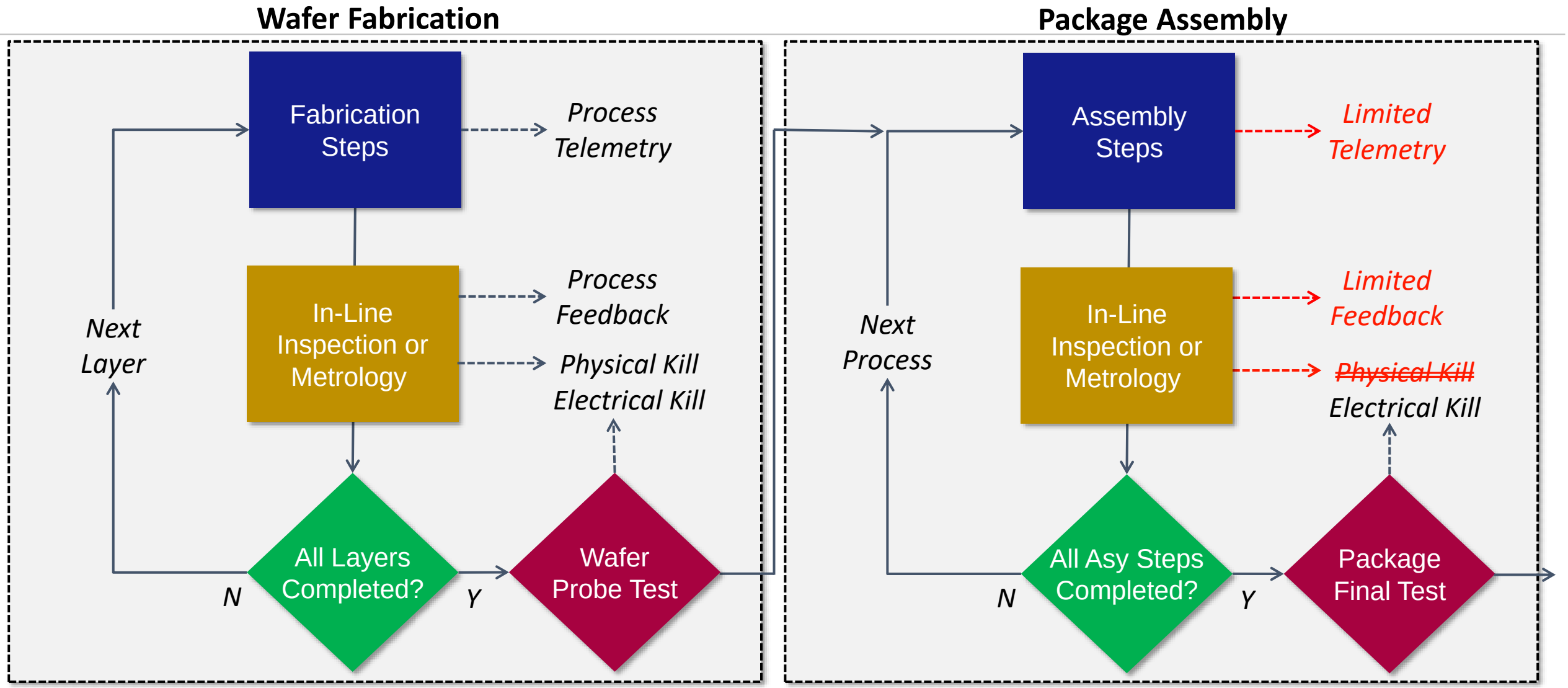
Package Asy

1970's~1980's | 1980's~1990's | 1990's~2000's | 2000's~2010's

Quality Systems Comparison

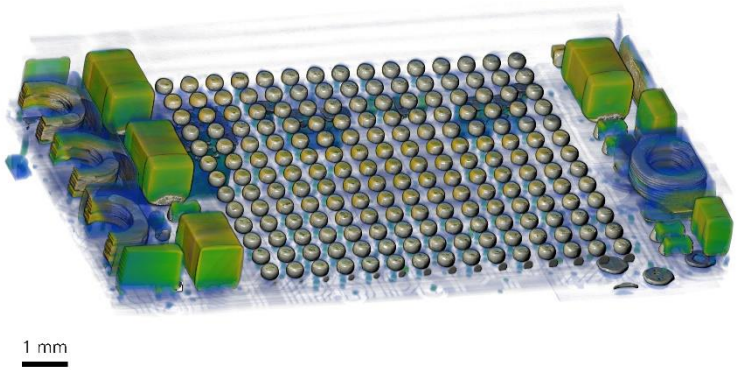


Quality Systems Comparison

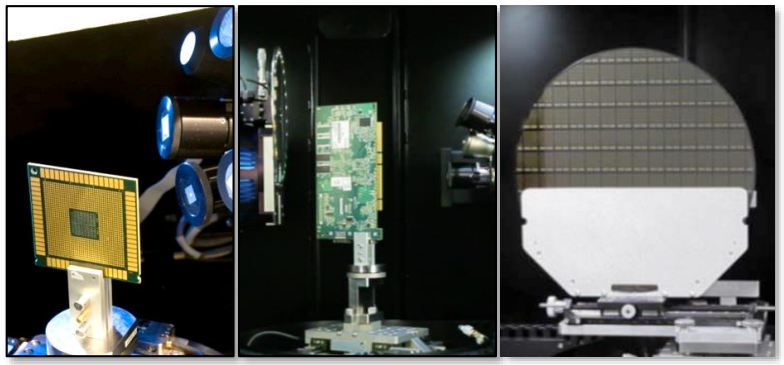


ZEISS 3D X-ray Solutions for Packaging

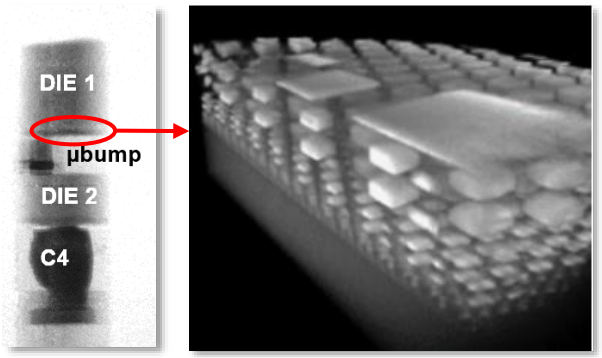
	microCT (upgradeable to Versa)	Next Generation Versa XRM	Ultimate Nanoscale XRM
			
	Context	**600-series Versa**	**800 Ultra**
Resolution:	950 nm	500 nm	150 nm, 50 nm



Large field of view for all samples, high resolution for small samples

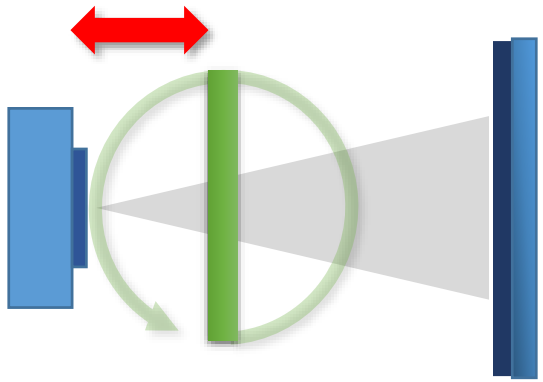


Versatile submicron 3D resolution on a variety of intact samples



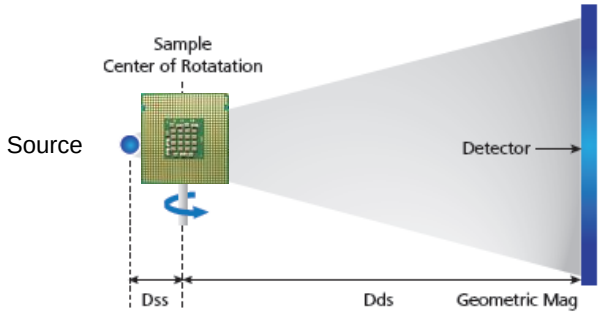
Nanoscale resolution for imaging ultra-fine pitch interconnects

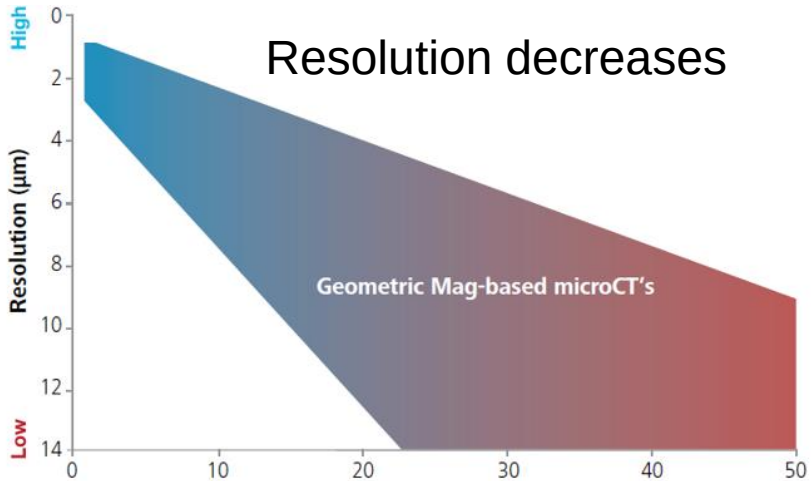
Versa X-ray Microscope vs. microCT



Working distance must increase as package body size increases

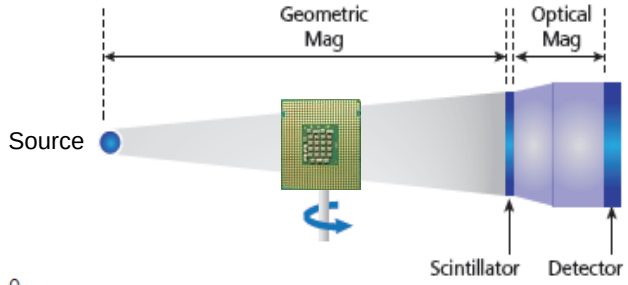
microCT

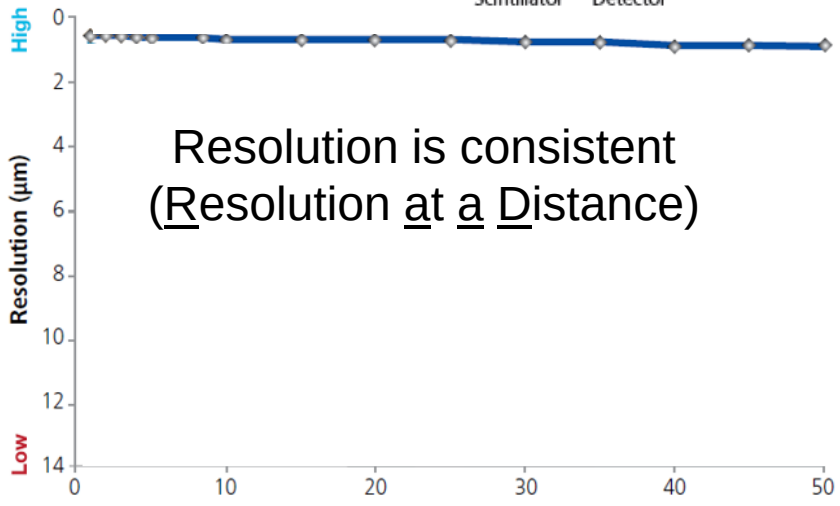




Resolution decreases

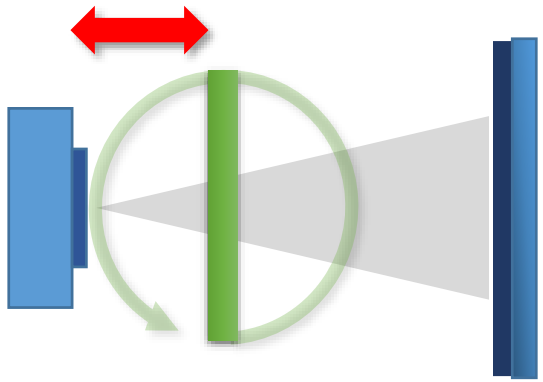
Versa XRM





Resolution is consistent
(Resolution at a Distance)

Versa X-ray Microscope vs. microCT



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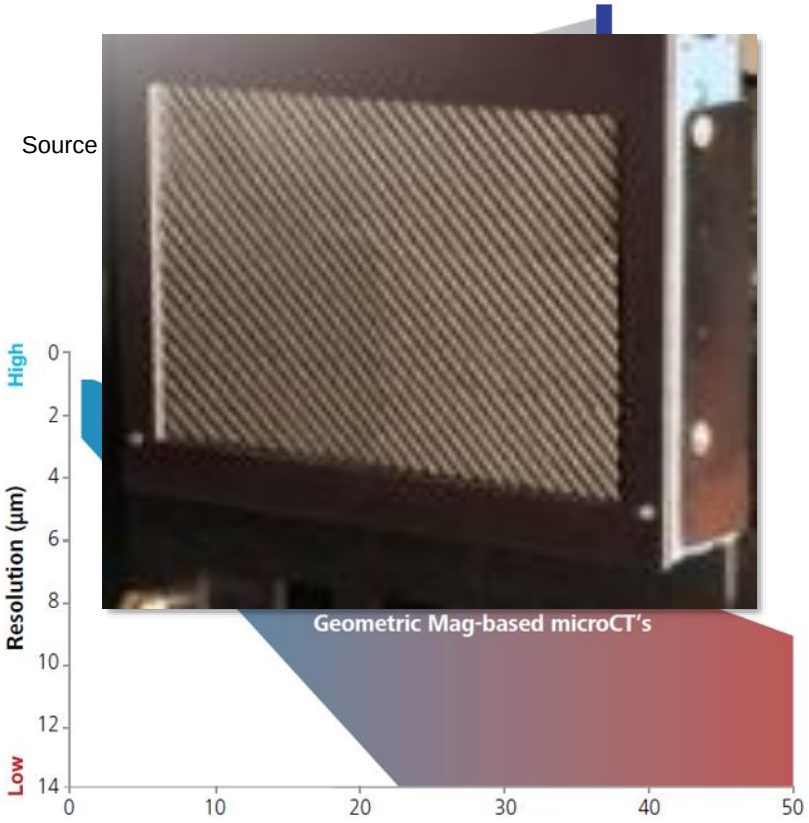
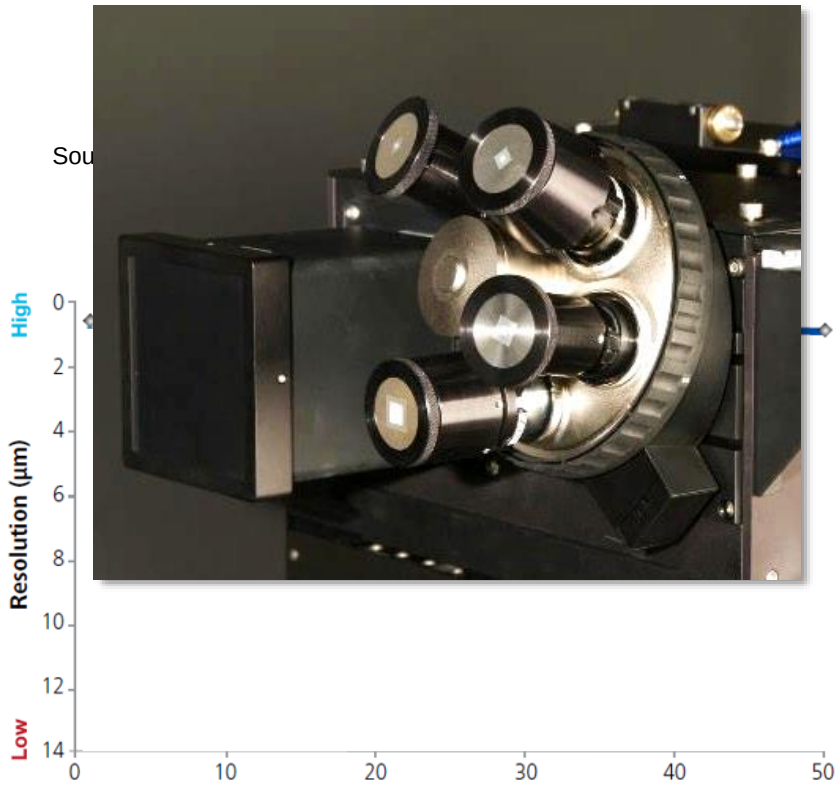
microCT



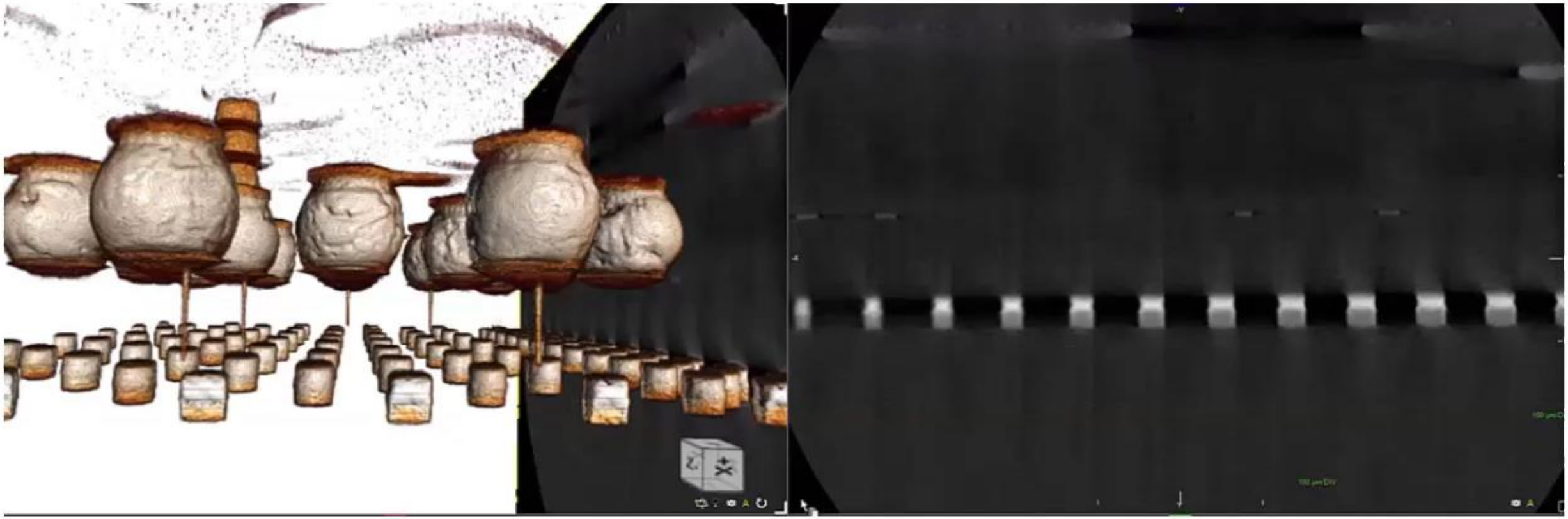
Versa XRM



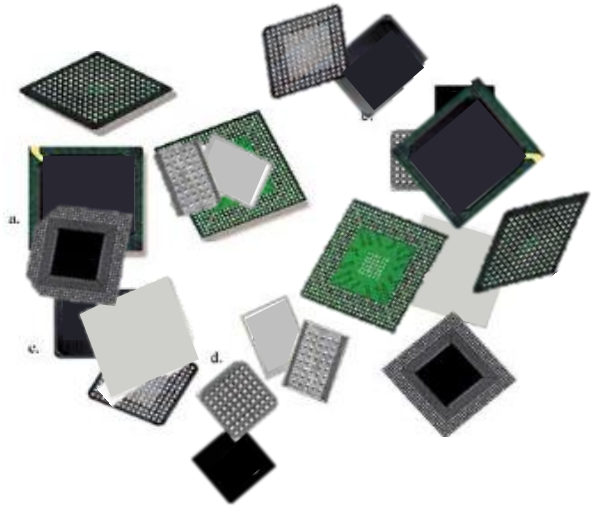
Versa XRM 3D Dataset and Virtual Cross Section

3D Dataset

Interactive Virtual Cross Section

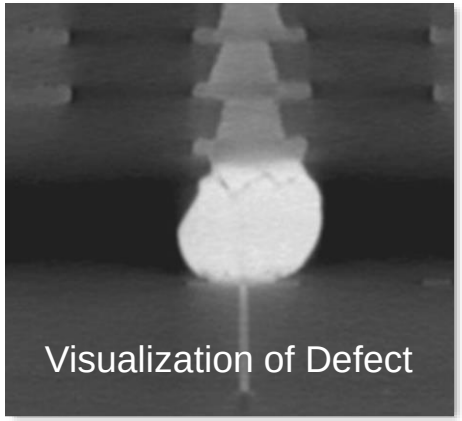


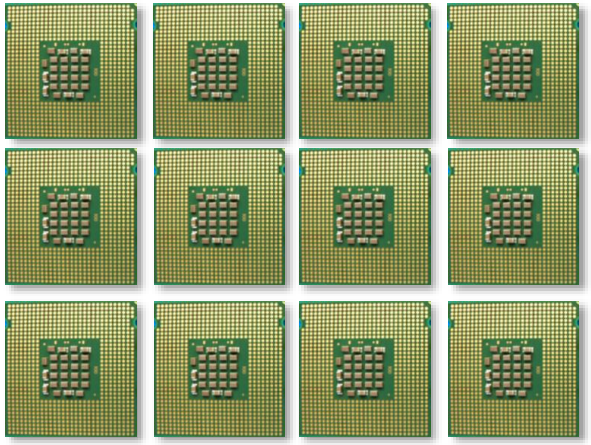
Failure Analysis and Package Characterization



Failure Analysis

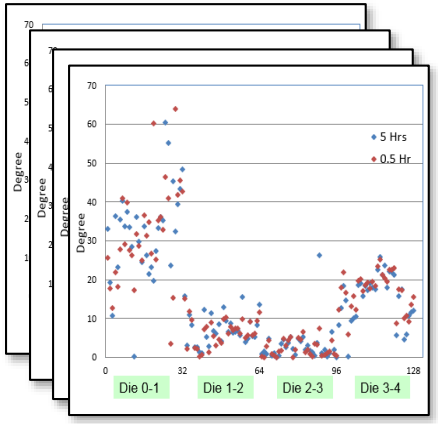
- Root-cause analysis
- Usually 1~2 samples per job
- Each scan is unique
- Objective is defect visualization



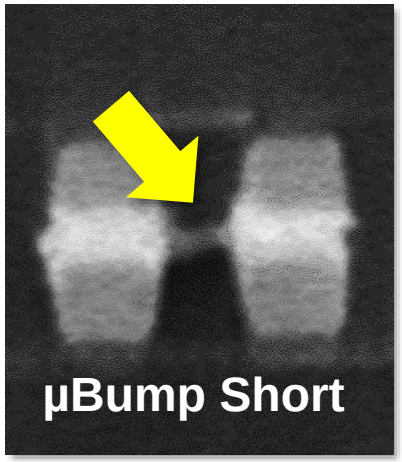


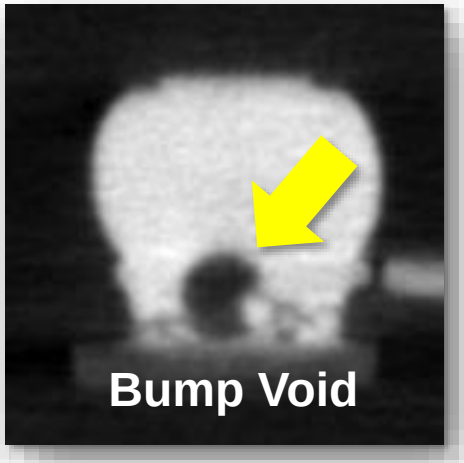
Package Characterization

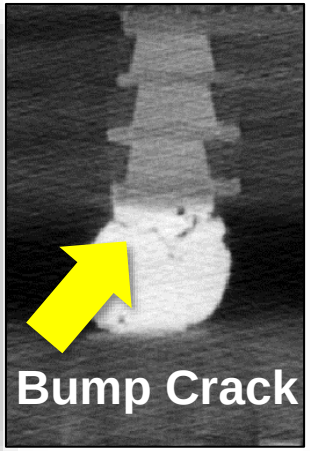
- Construction and process analysis
- Multiple samples per job (DOE's, etc.)
- Scans are often repeated
- Objective is measurement of critical parameters

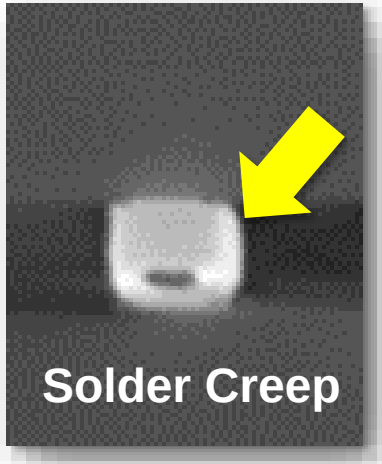


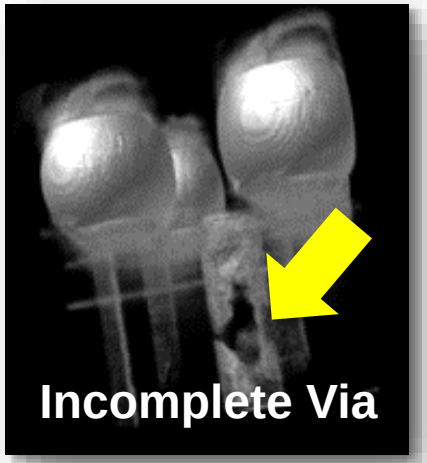
The Most Versatile 3D X-ray System in the Industry!

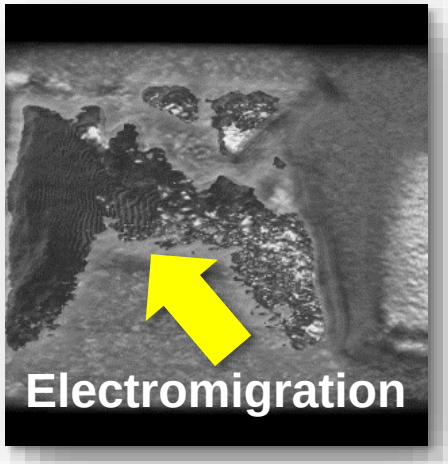


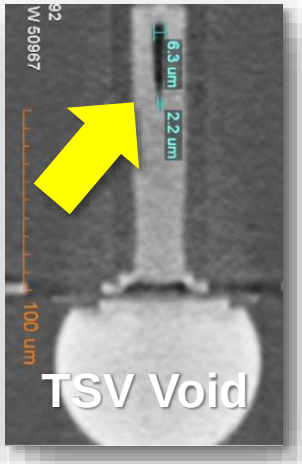


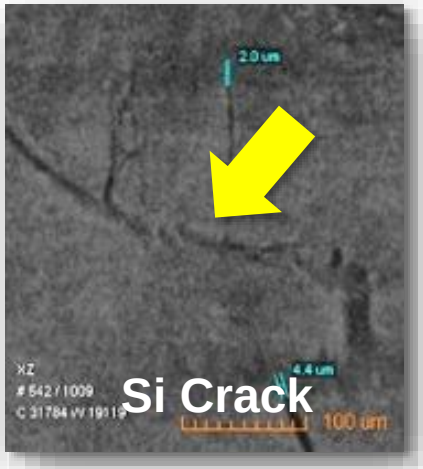




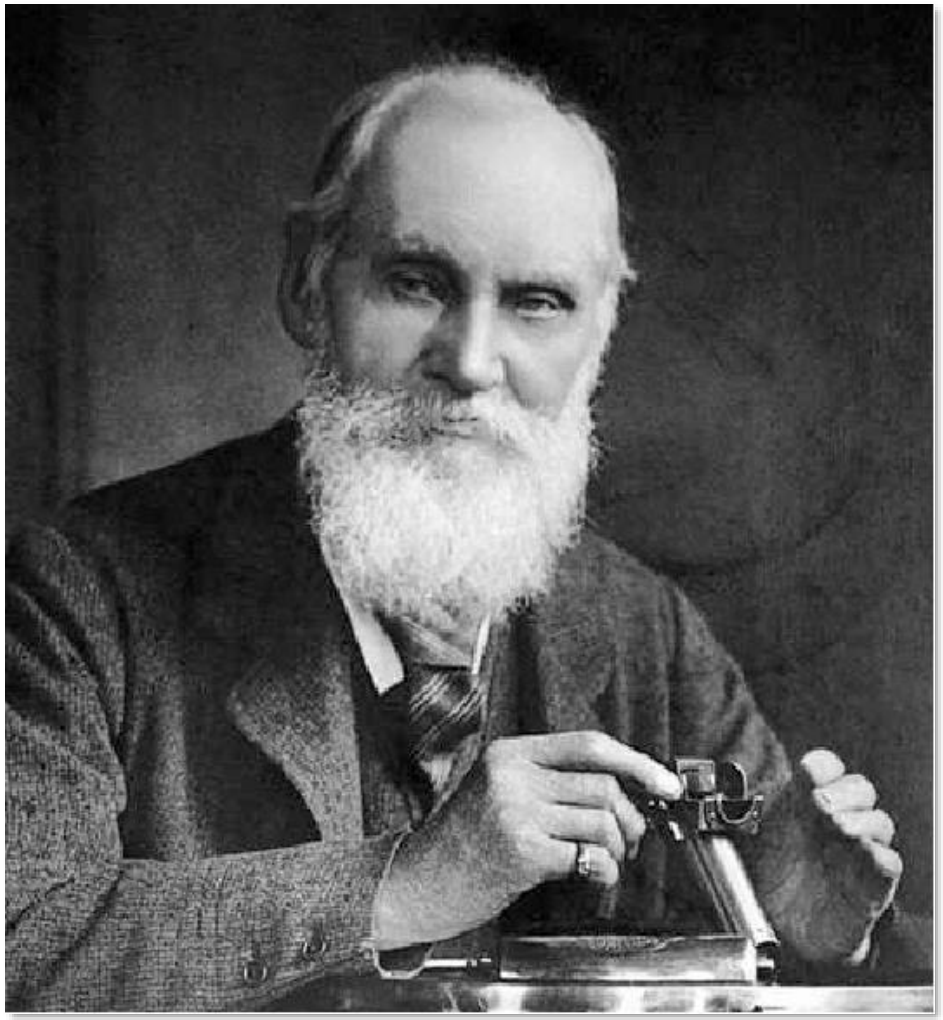








Lord Kelvin (William Thomson)

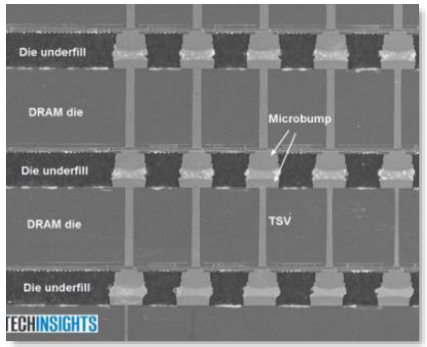


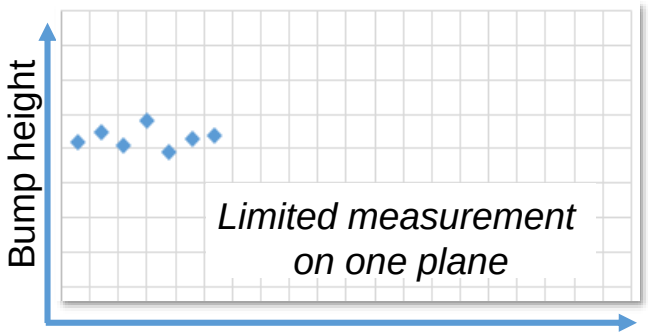
…when you can measure what you are speaking about, and express it in numbers, you know something about it…

Lecture on “Electrical Units of Measurement”, May 2, 1883

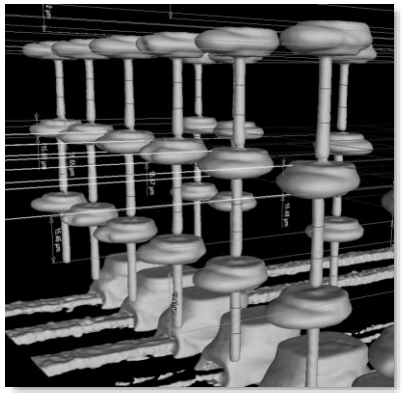
3D X-ray for Inspection and Measurement of Buried Features

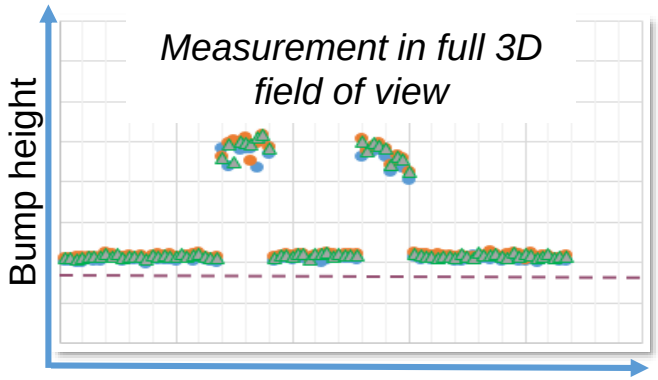
Physical Cross-Section Measurement





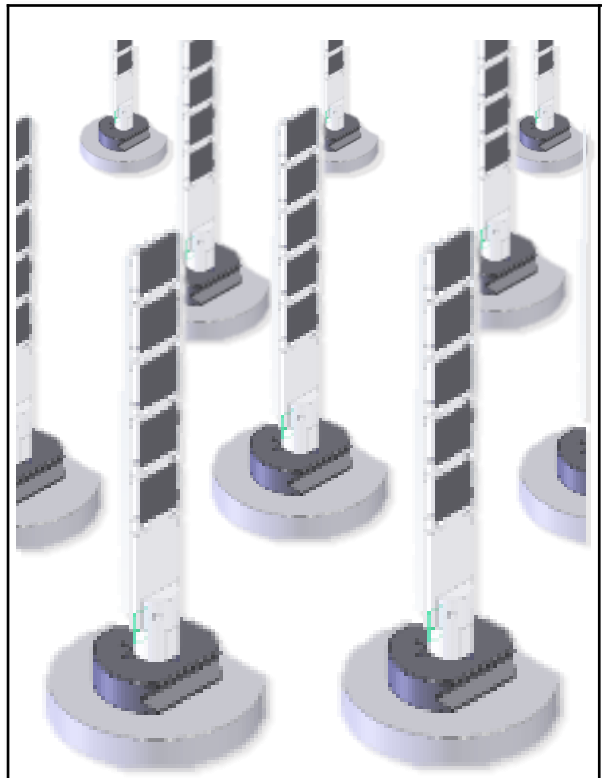
X-ray Microscopy Measurement





- High-resolution tomography images with automated, repetitive scanning for same package design and location
- Measurement software and ZEISS support enable semi-automated 3D linear and volumetric measurements
- 3D enables many types of metrologies: solder volume, shape, extrusion analysis…

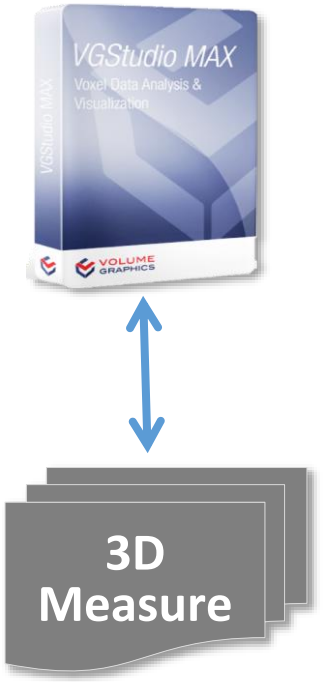
Versa XRM Measurement Workflow



Load Parts in Robotic System

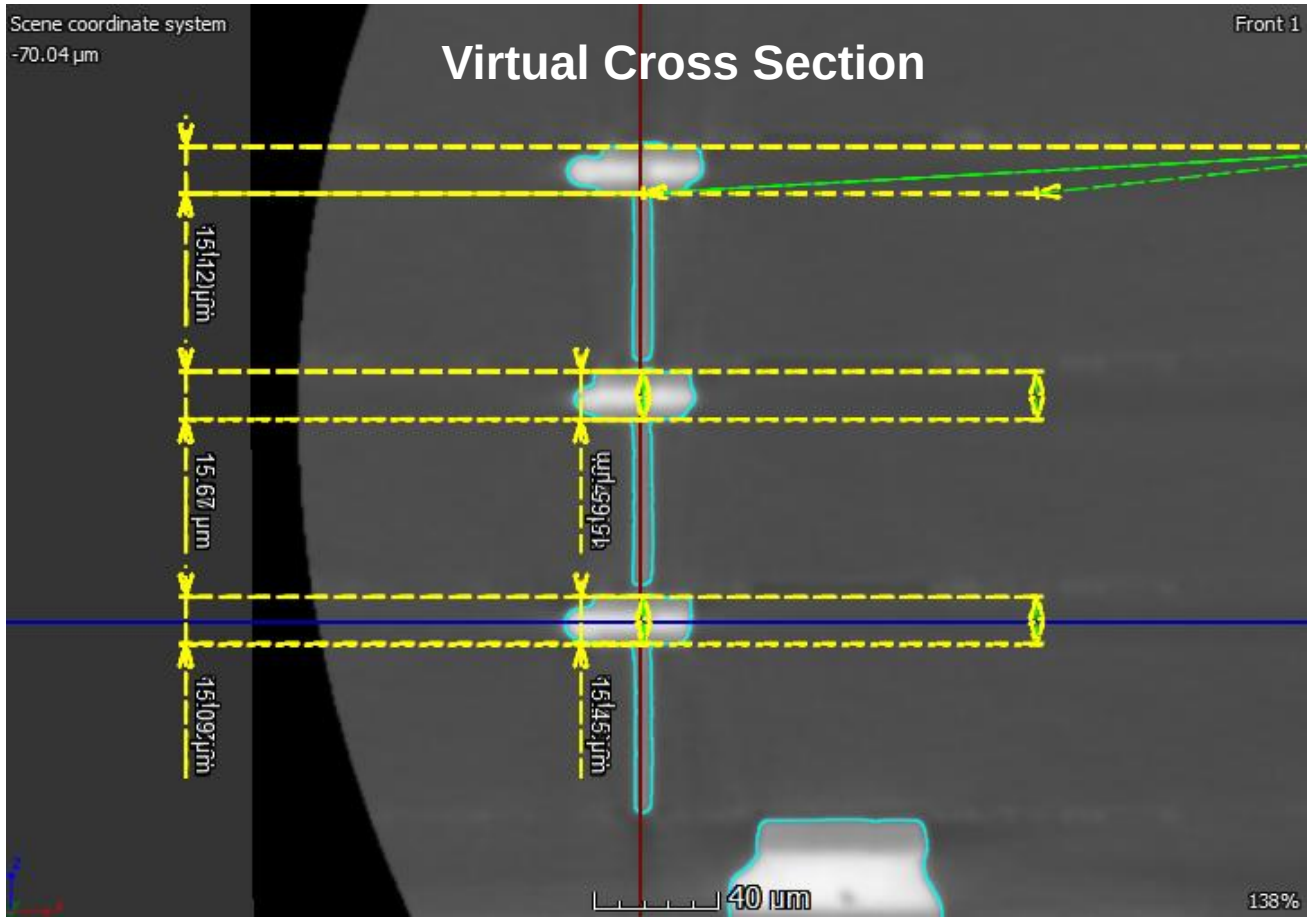
Automatic Acquisition and Reconstruction

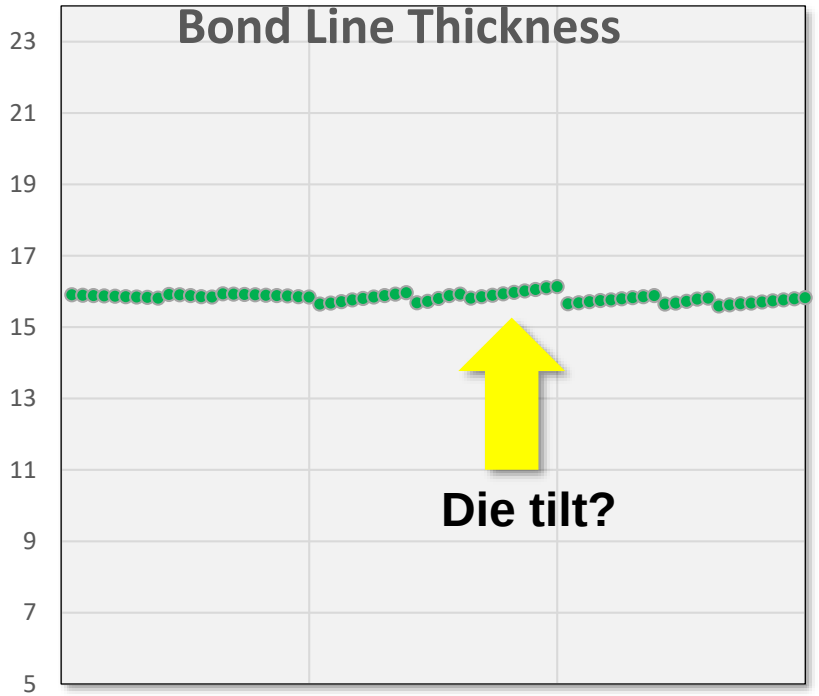
Mass Data Storage



Repetitive Measurement

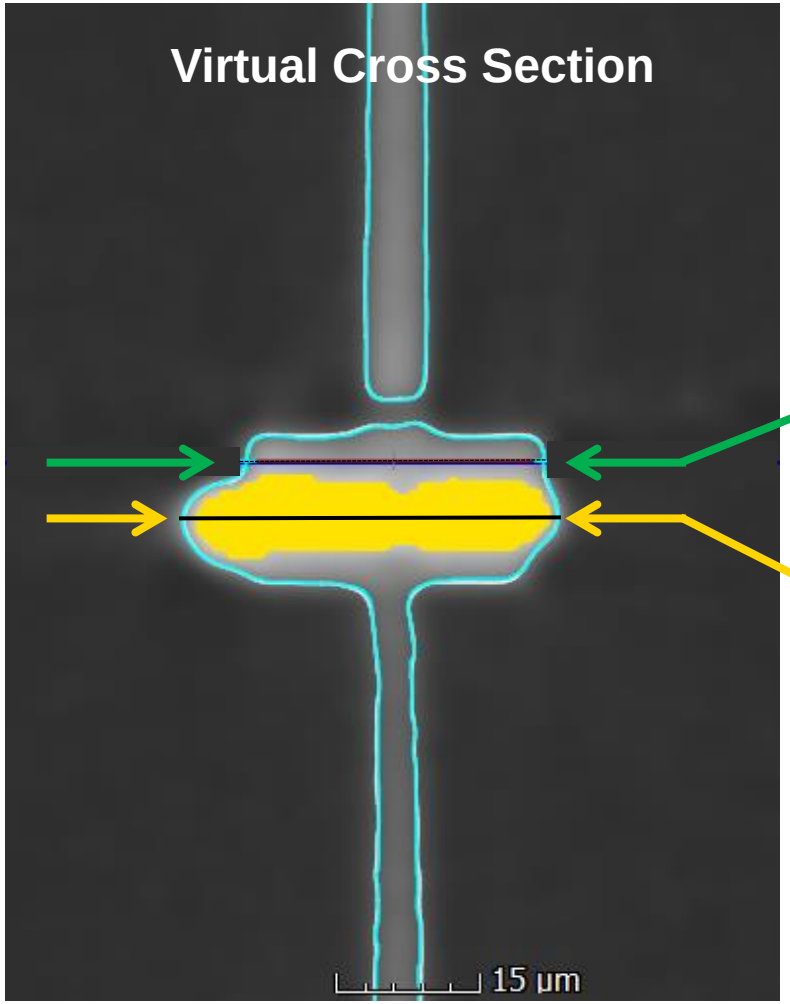
Case Study #1: µBump TCB Bond Line Thickness

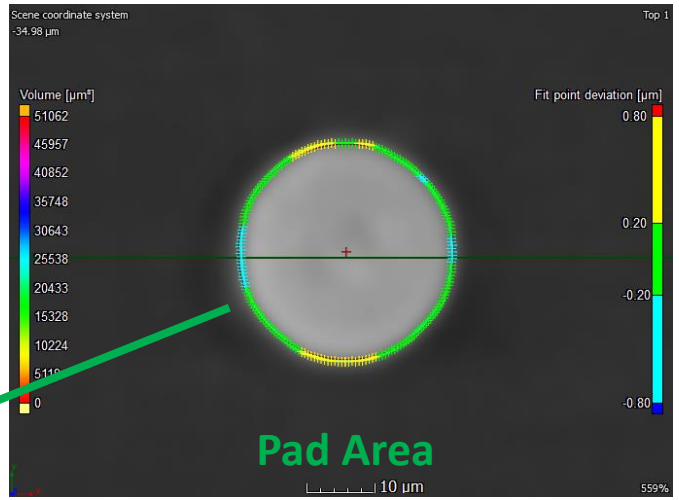


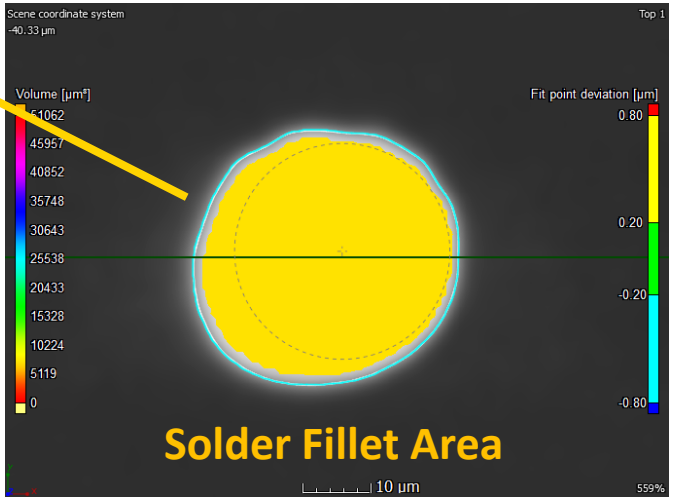


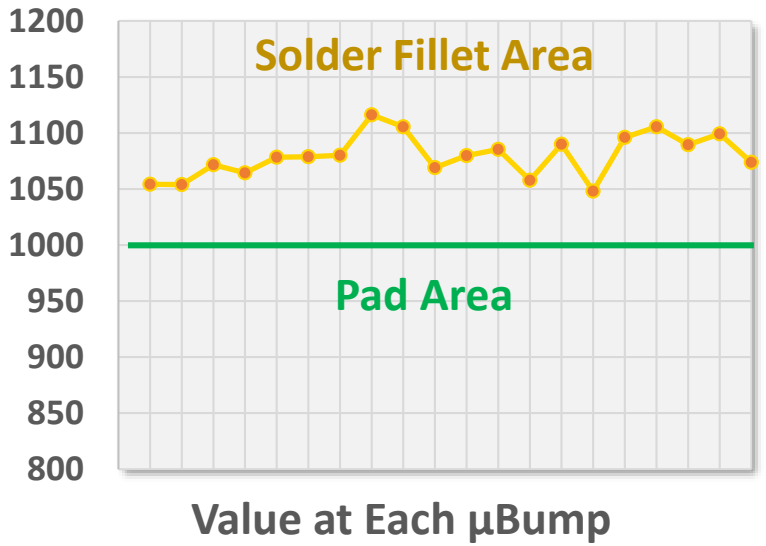
Bond line thickness (BLT) is defined by die-to-die distance

Case Study #2: µBump Solder Fillet Geometry



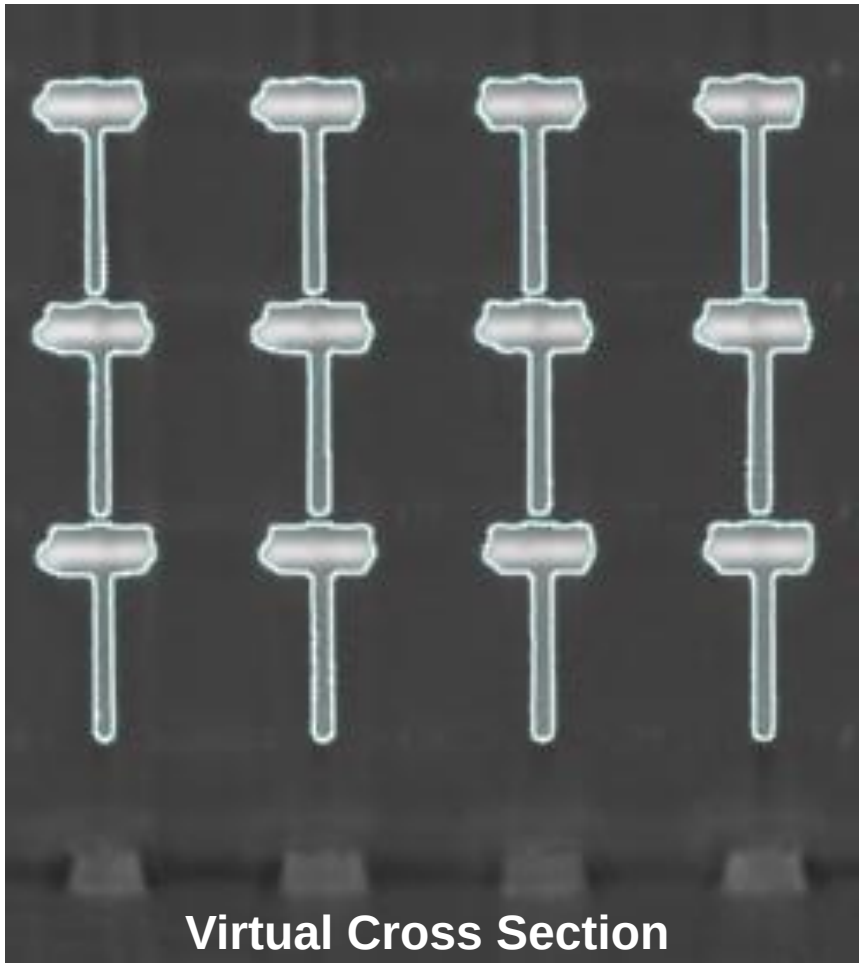


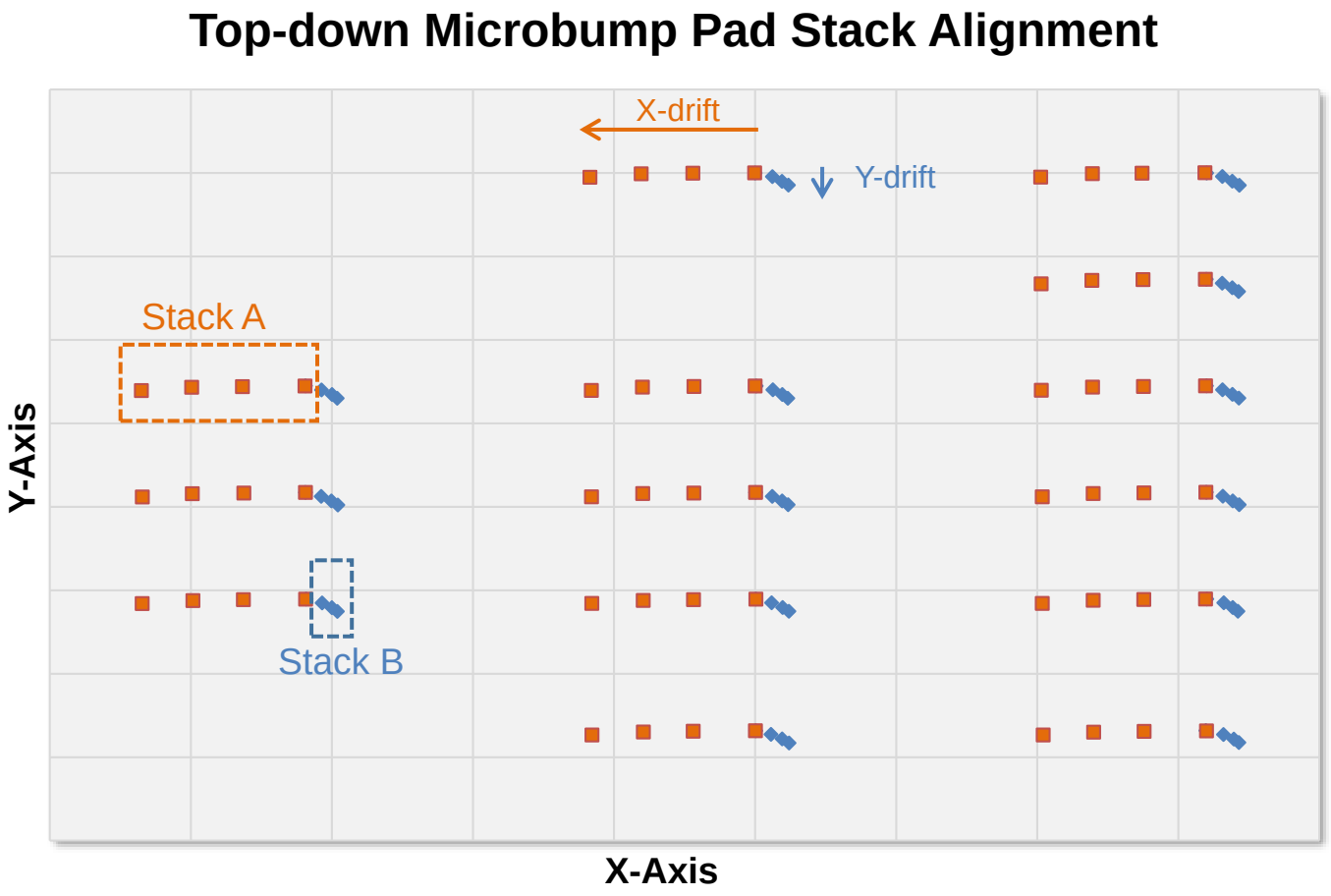




Value at Each µBump

Case Study #3: TSV Array Alignment Analysis





Use of Versa 3D X-ray for Package Measurement

Results in faster, more accurate package development for on-time, on-target product launches by enabling:

- Larger inspection and measurement sample quantities for more robust process optimization
- More accurate, more comprehensive metrology compared to manual cross-section
- Statistically-valid DOEs, process splits and other statistical techniques
- Ability to analyze the same samples both before and after stress testing
- And lower buried costs!

For more information contact:
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