The AI Revolution Through the Lens of Microscopy

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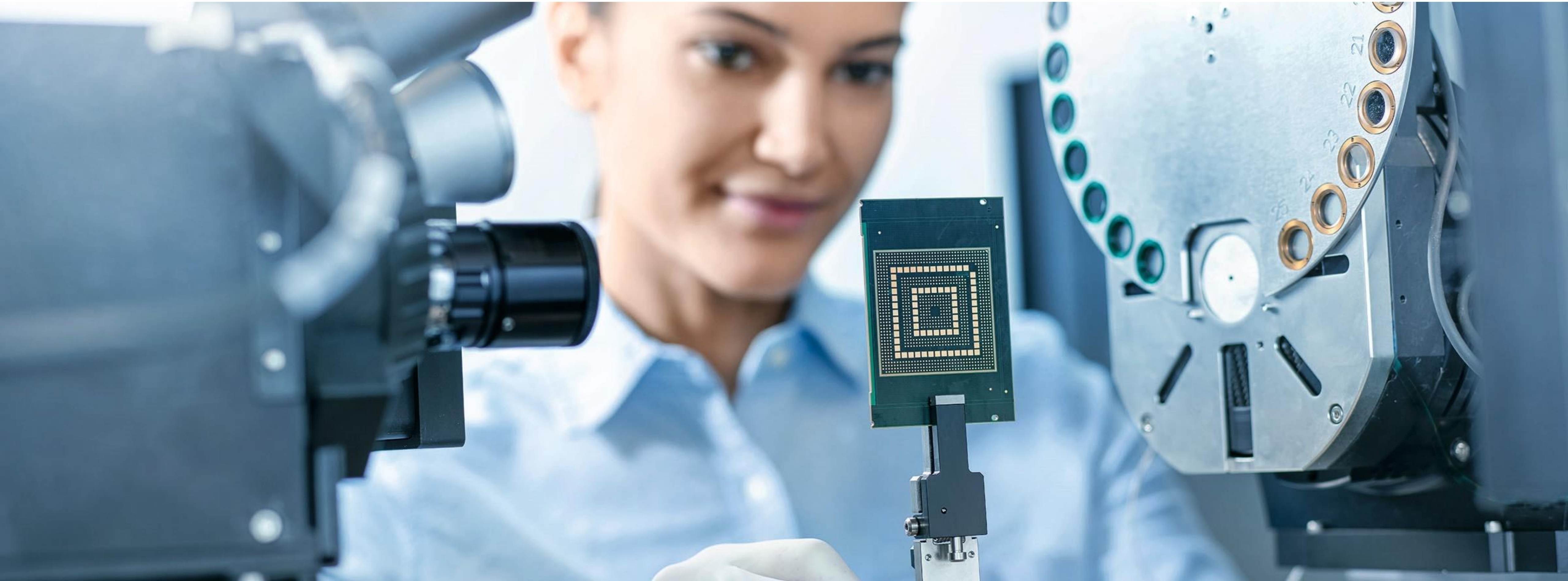
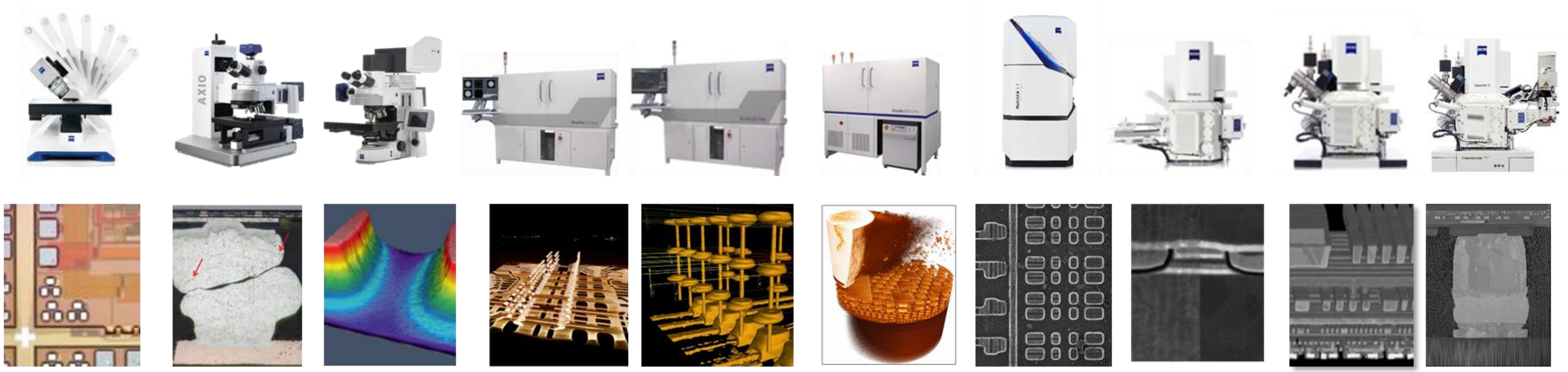
11 June 2024



Agenda

Introduction to ZEISS

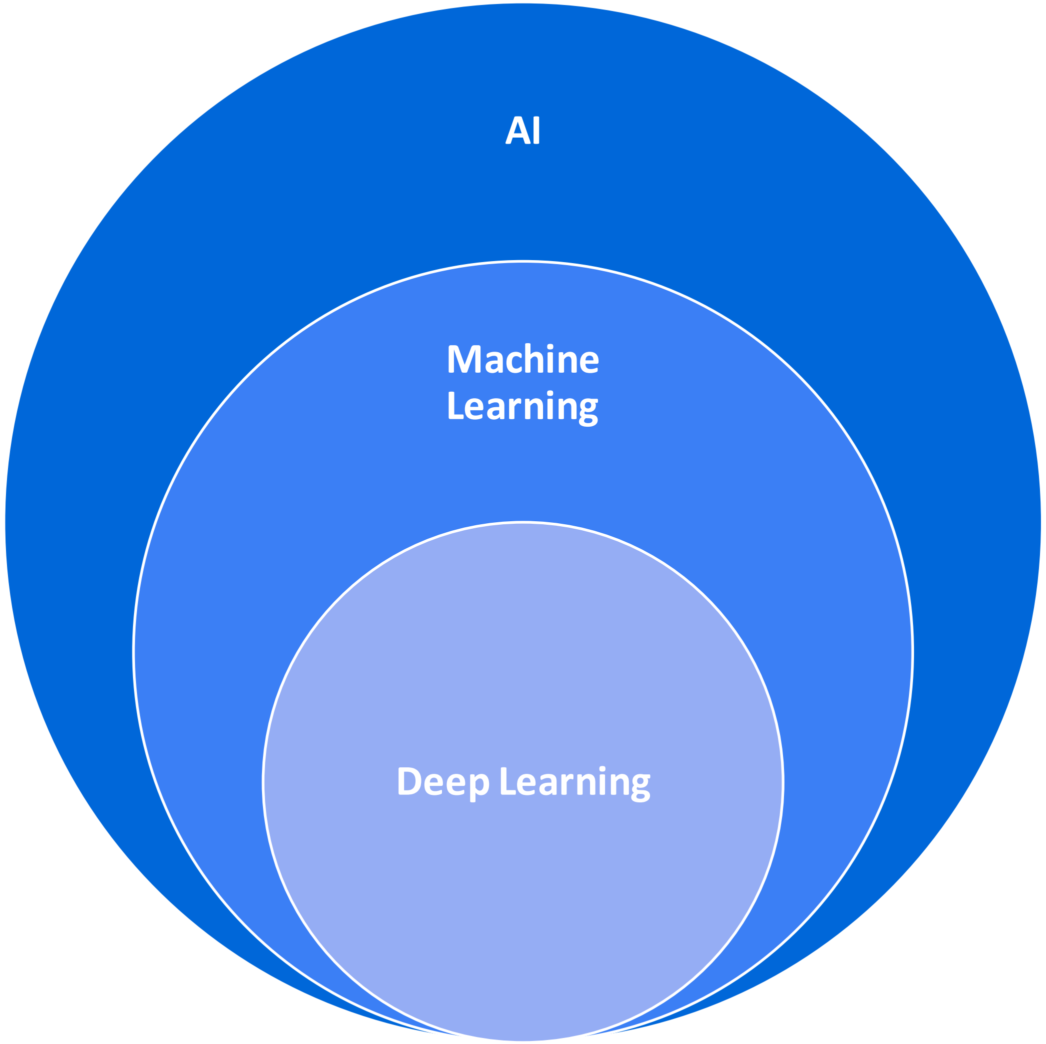
ZEISS Microscopy
Portfolio Across Lengthscales



Digital Microscope	Upright and Inverted	Confocal	Submicron microCT	Submicron 3D X-ray	Nanoscale 3D X-ray	Multi-beam SEM	FE SEM	Focused Ion Beam	Laser FIB
250 nm	250 nm	200 nm	950 nm	500 nm	50 nm	<4 nm	<1 nm	<1 nm	<1 nm

AI in Microscopy

AI Concepts



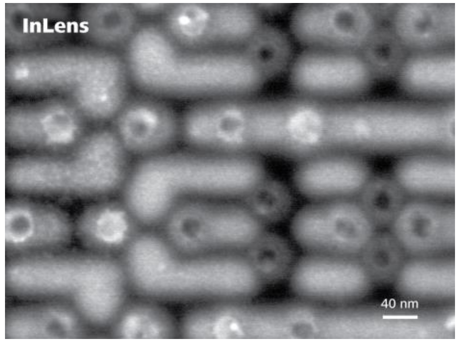
Machine Learning	Requirements	Deep Learning
Yes	**Training**	Yes
Medium	**Size of training dataset**	Large
Medium	**Processing power**	High

Stages in a Microscopy Workflow
Advanced Reconstruction Toolbox

01

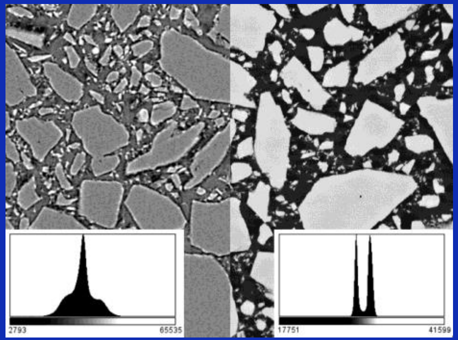
Sample Preparation

02



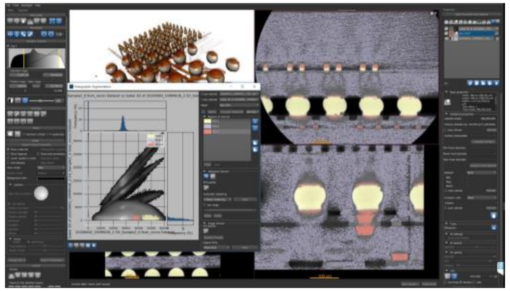
Imaging

03



Processing

04

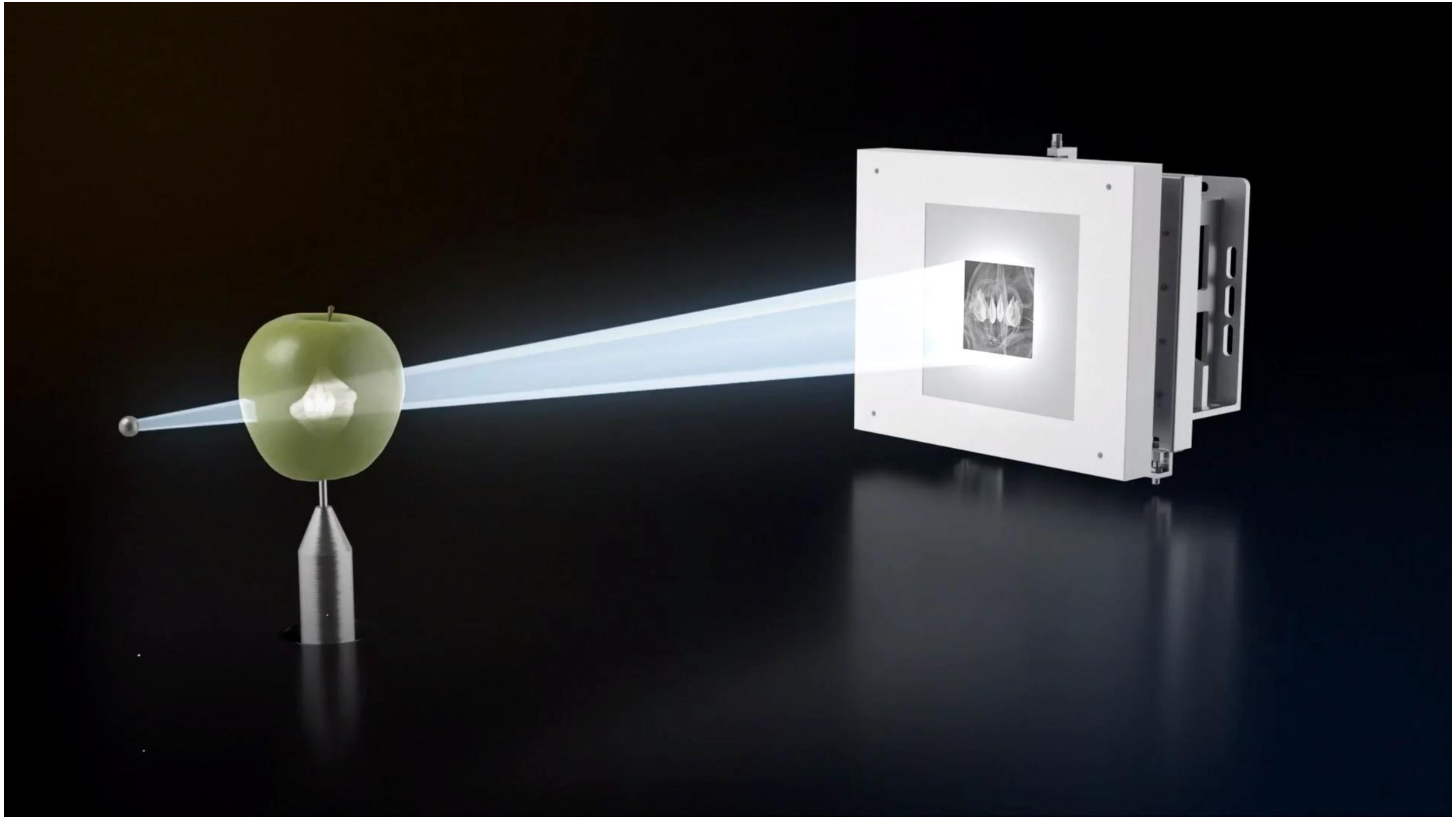


Data Analysis

Introduction to X-ray CT

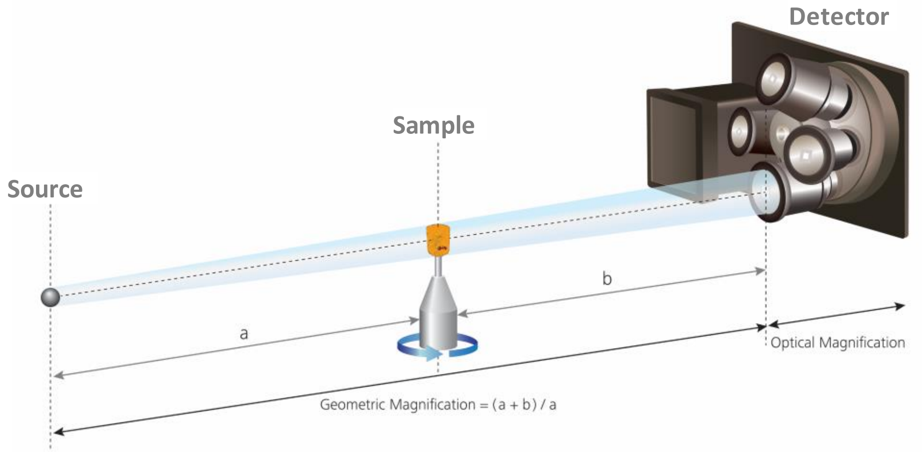
Conventional X-ray microCT

The intrinsic conflict is the resolution and the sample size

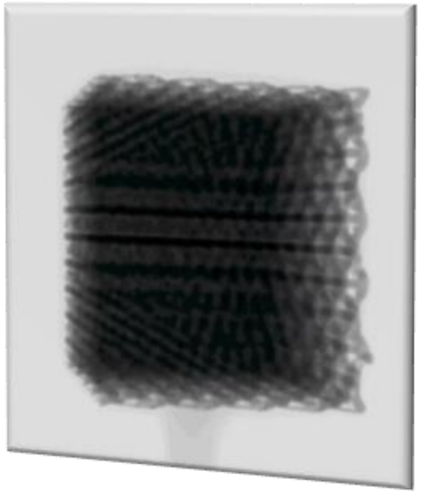


X-ray Computed Tomography

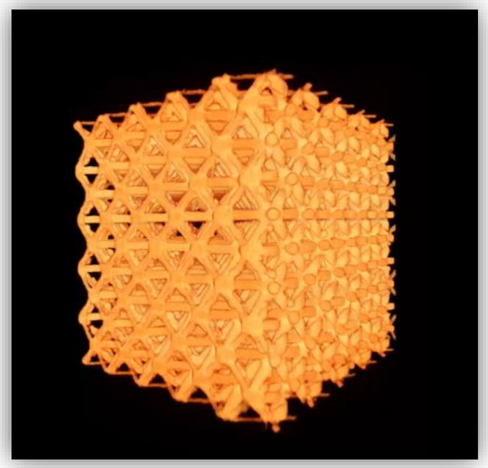
How this works



Projections

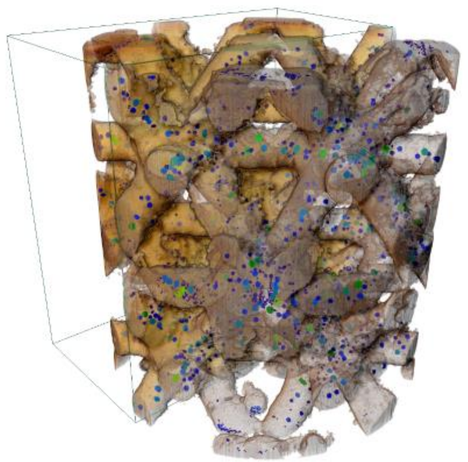


3D Reconstruction



Virtual slices

Quantitative Analysis



AI for CT Reconstruction

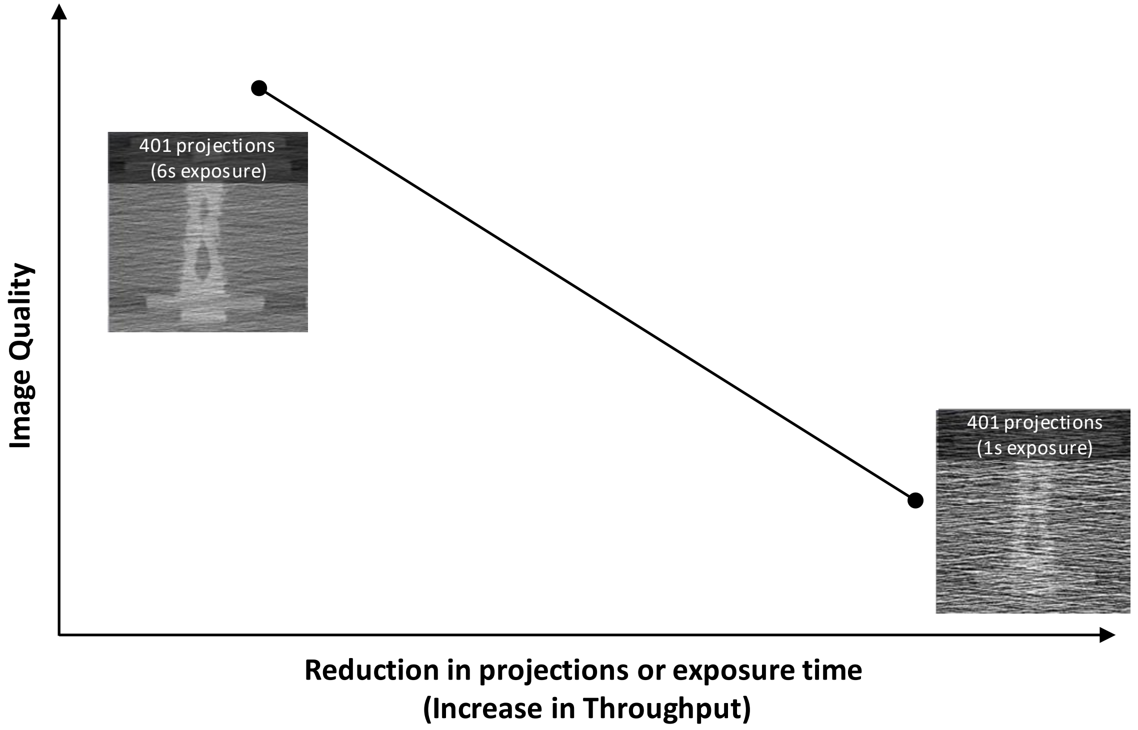
Standard Reconstruction Technologies

Standard Analytical Reconstruction

- Currently, XRM uses a standard analytical reconstruction technology known as Filtered Back-Projection also called as **FDK** (Feldkamp) to compute 3D volumes from the 2D projection images.

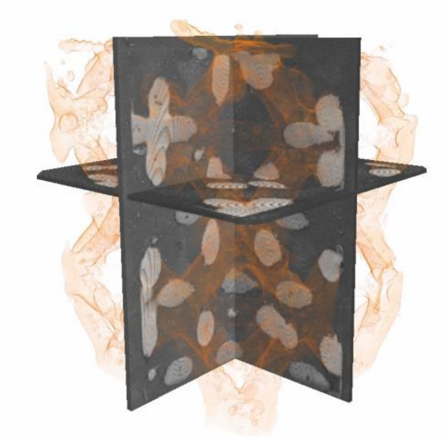
Key Limitations

- **Large number of projections** required to avoid limited angle artifacts → slower scan times
- **Long exposure times** required to avoid high noise artifacts → slower scan times

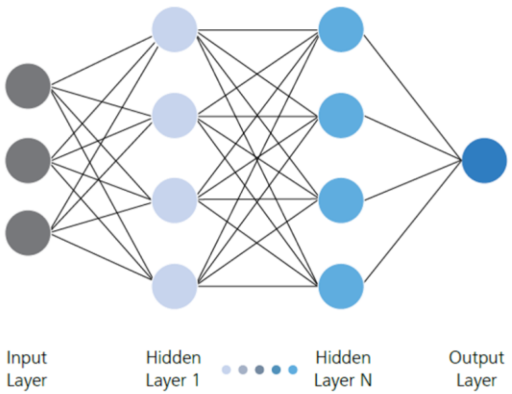


DeepRecon

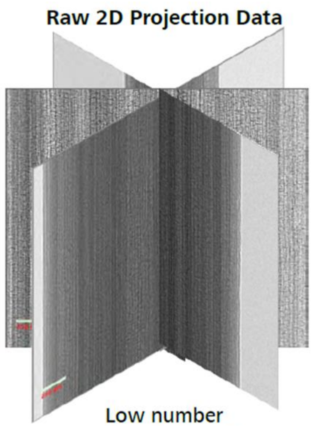
Capture Training Dataset <2 hrs



Train CNN Model

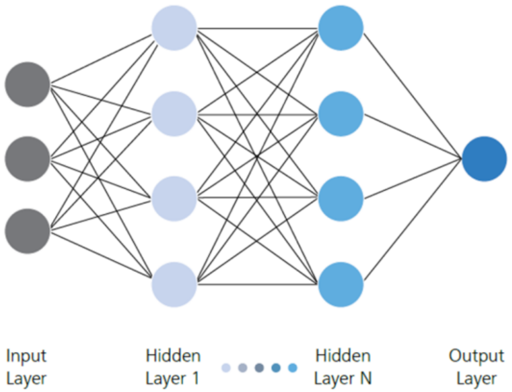


Capture Dataset

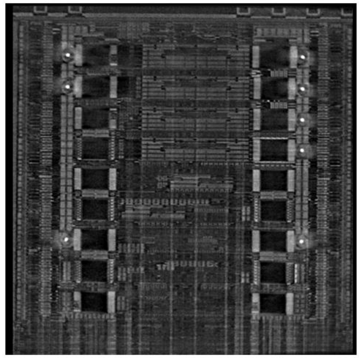


Low number
of projections /
exposure time

Apply CNN Model

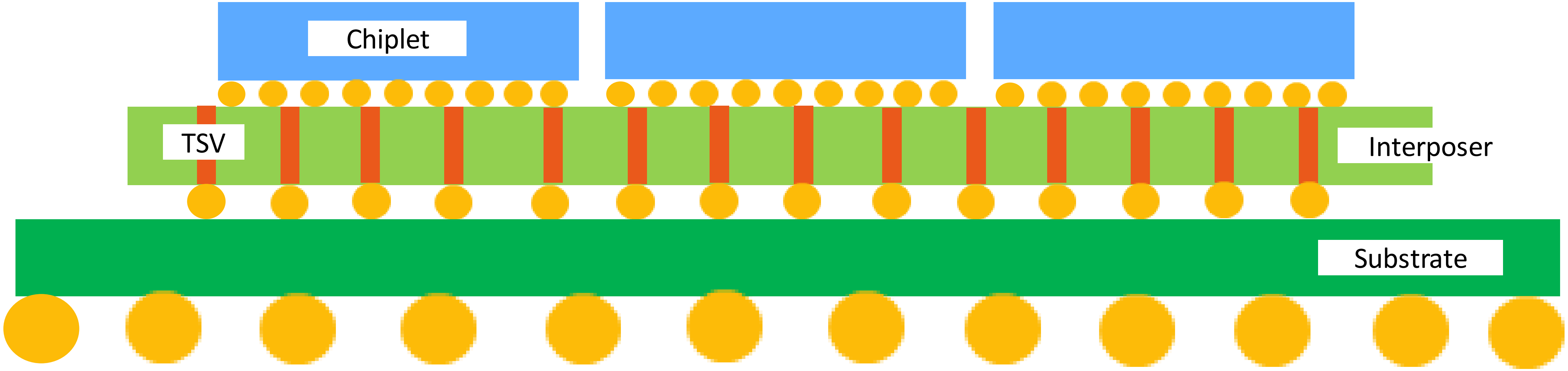


Recon Volume



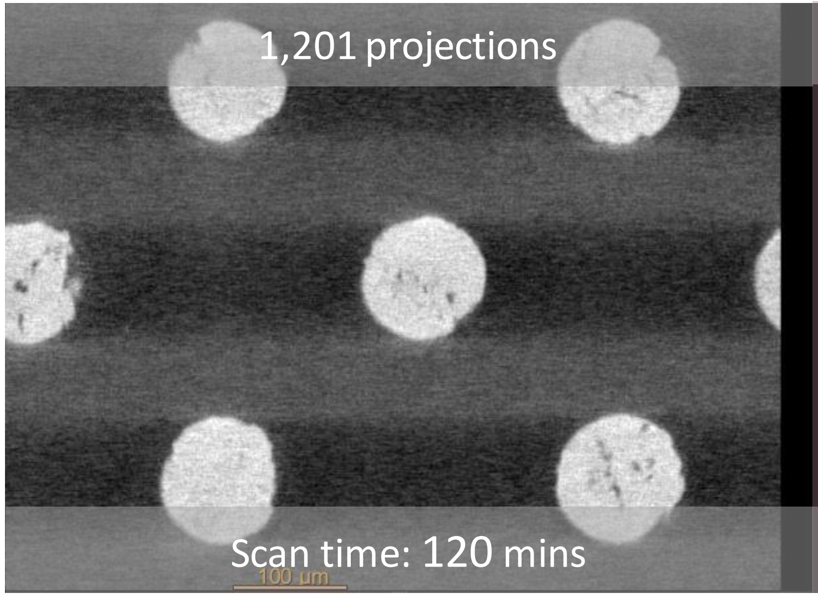
Low noise
High image quality

Invensas 2.5D Interposer Package

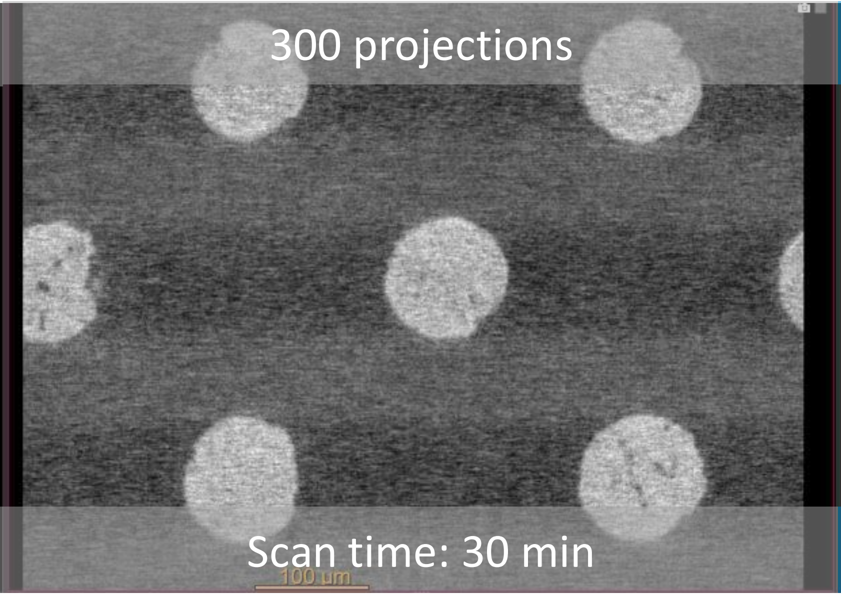


Results: 2.5D Interposer Package

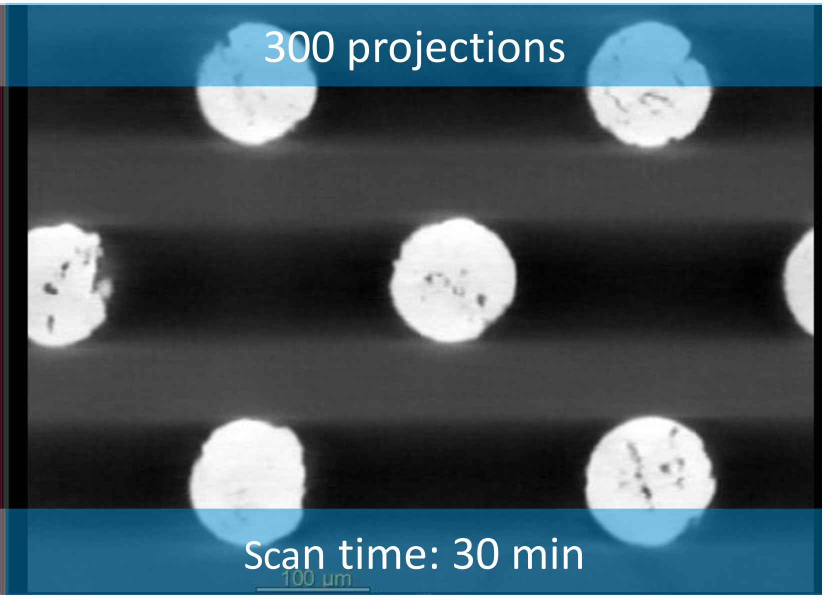
Standard Reconstruction



Standard Reconstruction

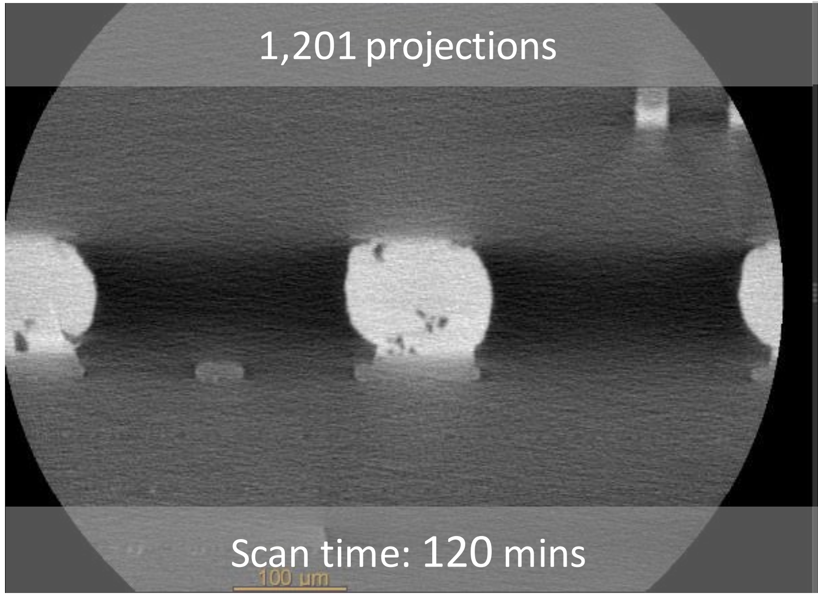


DeepRecon Pro

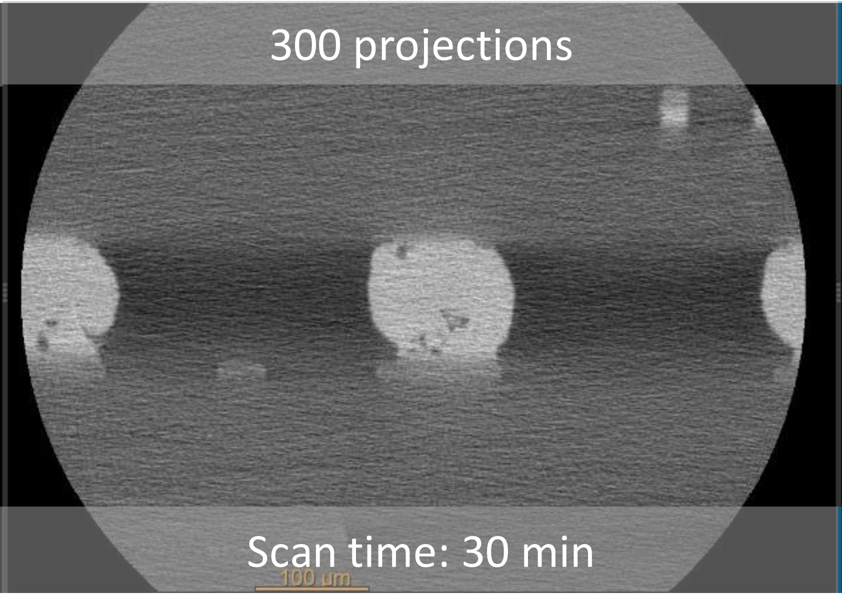


Results: 2.5D Interposer Package

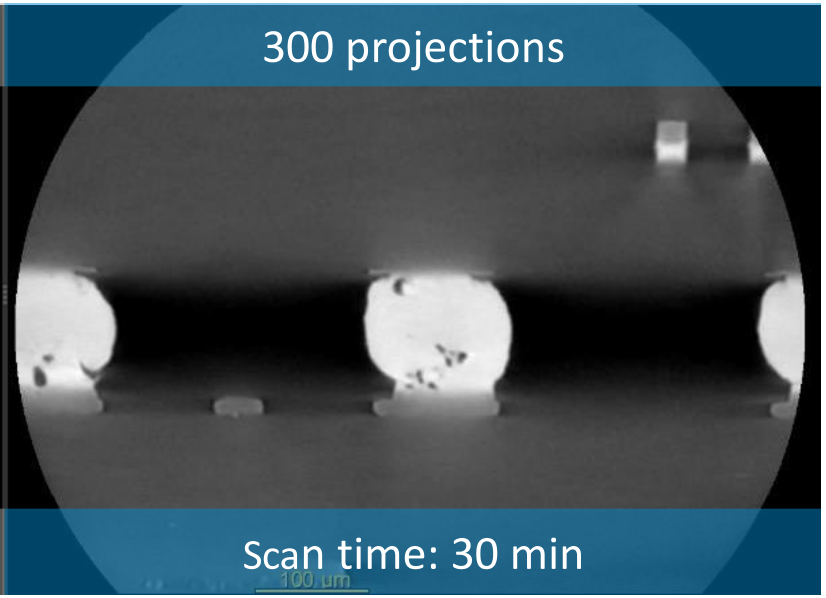
Standard Reconstruction



Standard Reconstruction

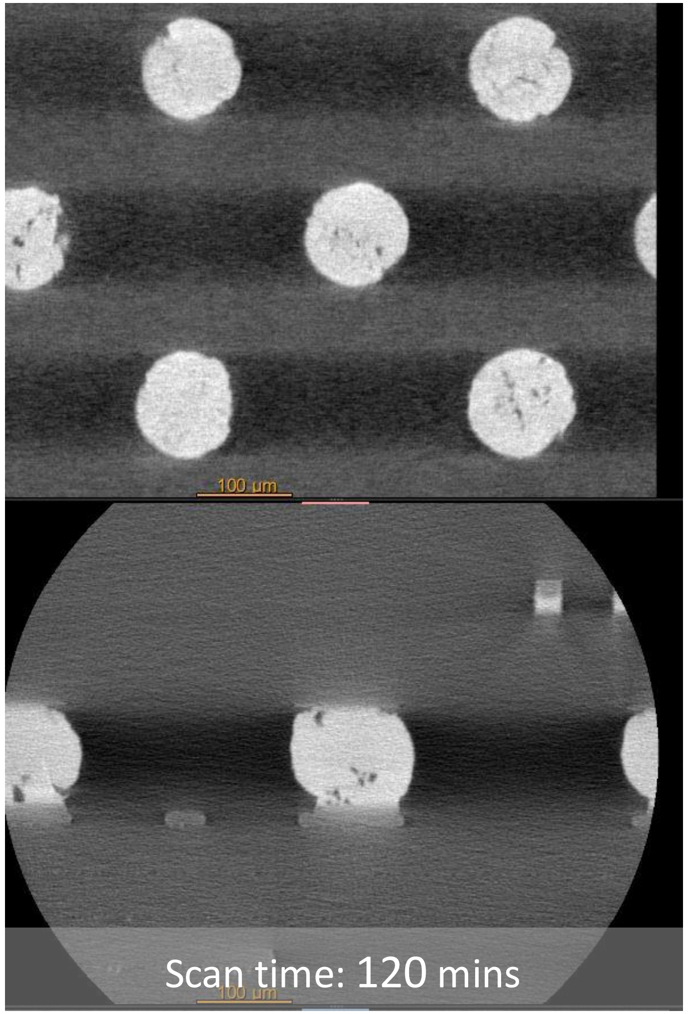


DeepRecon Pro

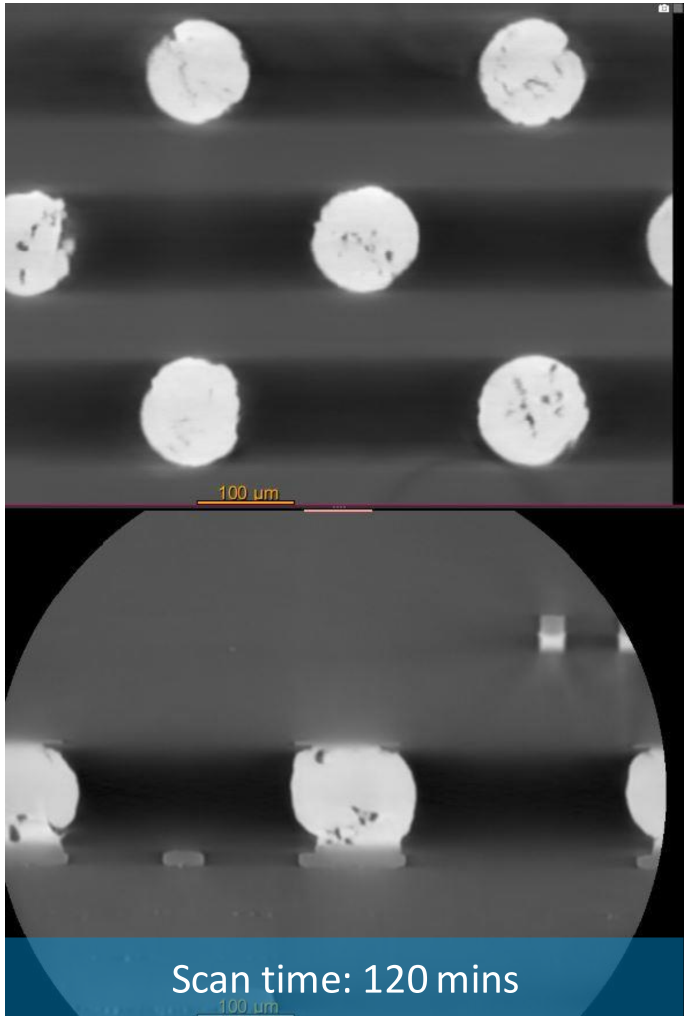


Results: 2.5D Interposer Package

Standard Reconstruction



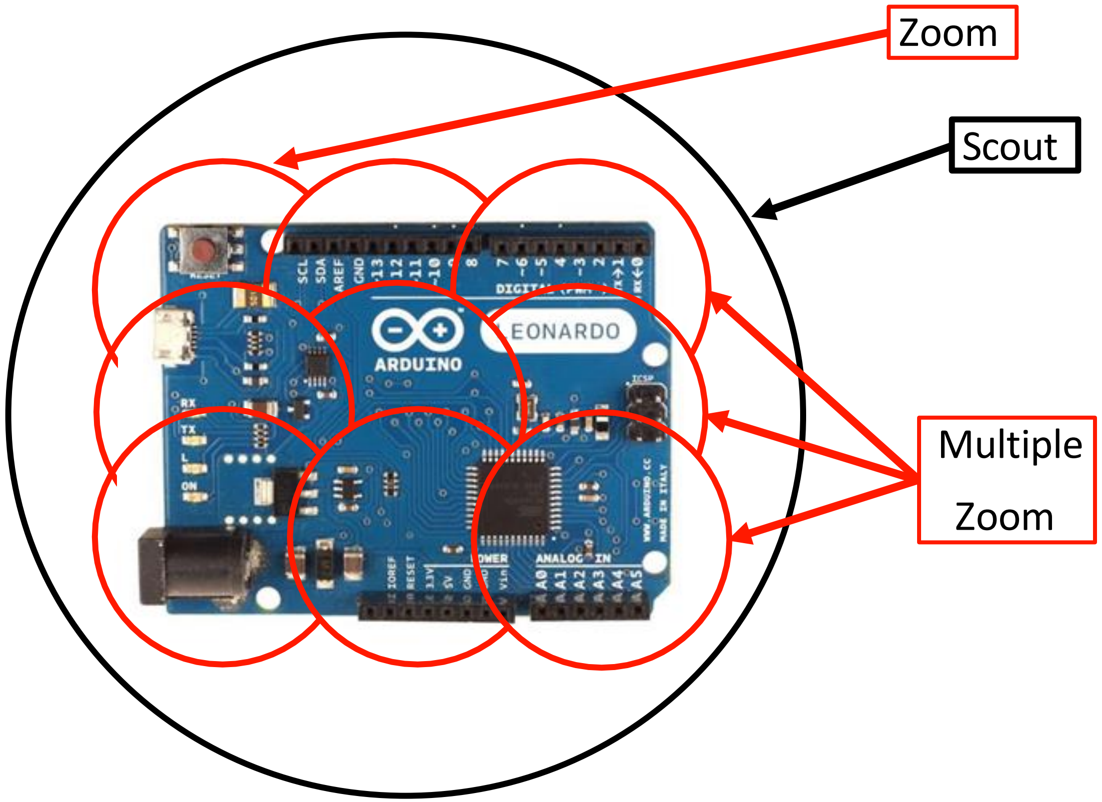
DeepRecon Pro



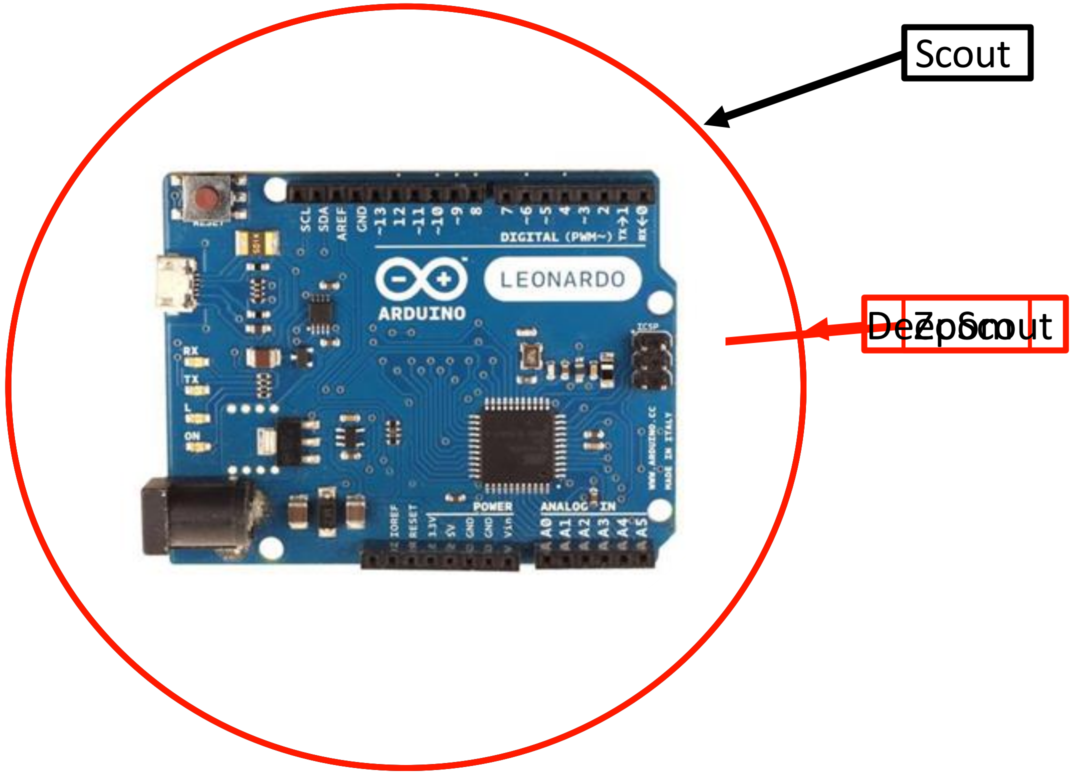
AI for Super-resolution

What is Super-resolution ?
High resolution across large fields of view

Because of the natural trade-off between resolution and field of view (FoV), high resolution across large fields of view is a true challenge for any microscope.

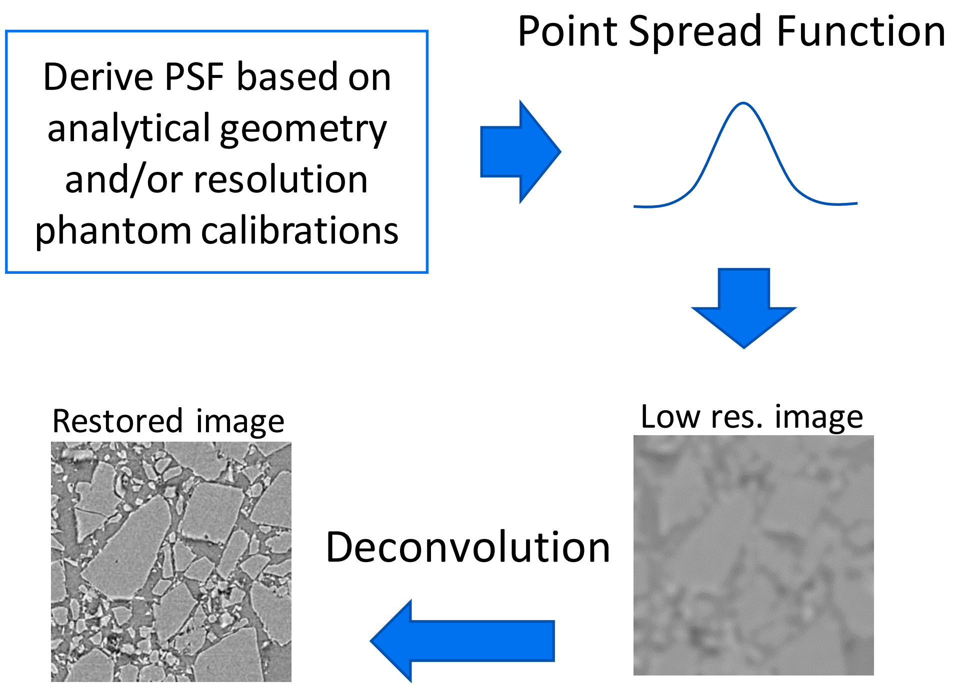


With DeepScout, it is possible to use DeepLearning based methods to recover resolution across large FoV.



How to improve spatial resolution

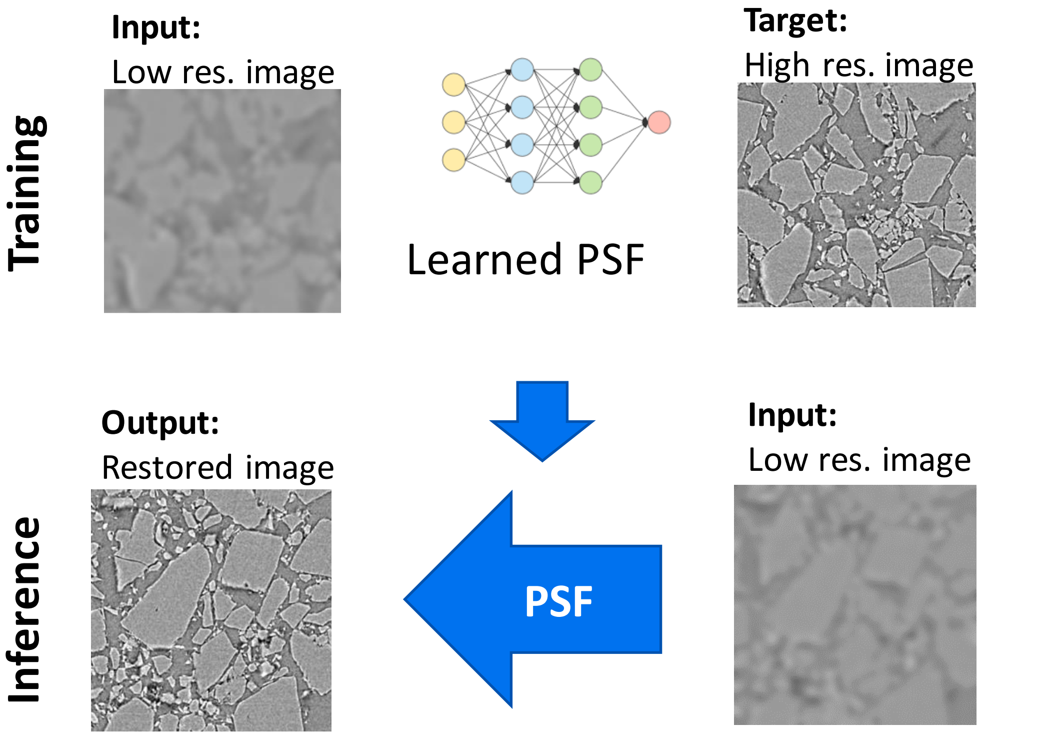
Classical: Analytical/Calibration



Problems with this approach:

- Approximations based on analytical geometry/phantom use may not fit actual sample and acquisition conditions
- Slow
- Increases noise
- Hard to account for anisotropic effects, scatter, etc.

Proposed: Machine Learning assisted



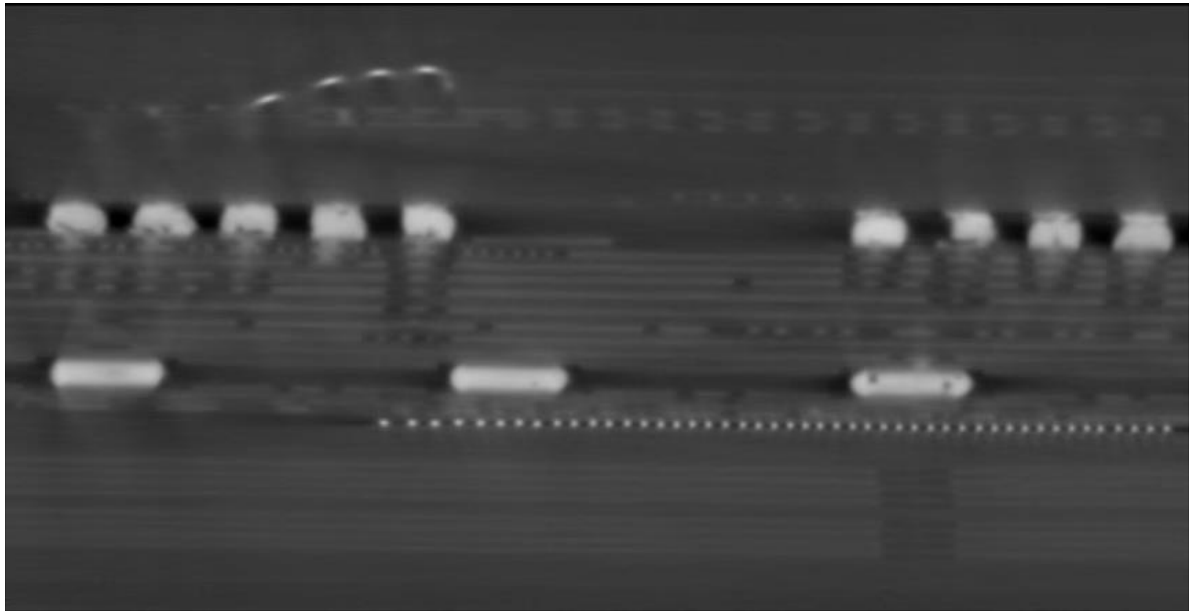
Benefits:

- Tailored to sample class and acquisition conditions
- Easy “calibration”
- Advanced network able to correct for a wide range of resolution effects without noise trade-off

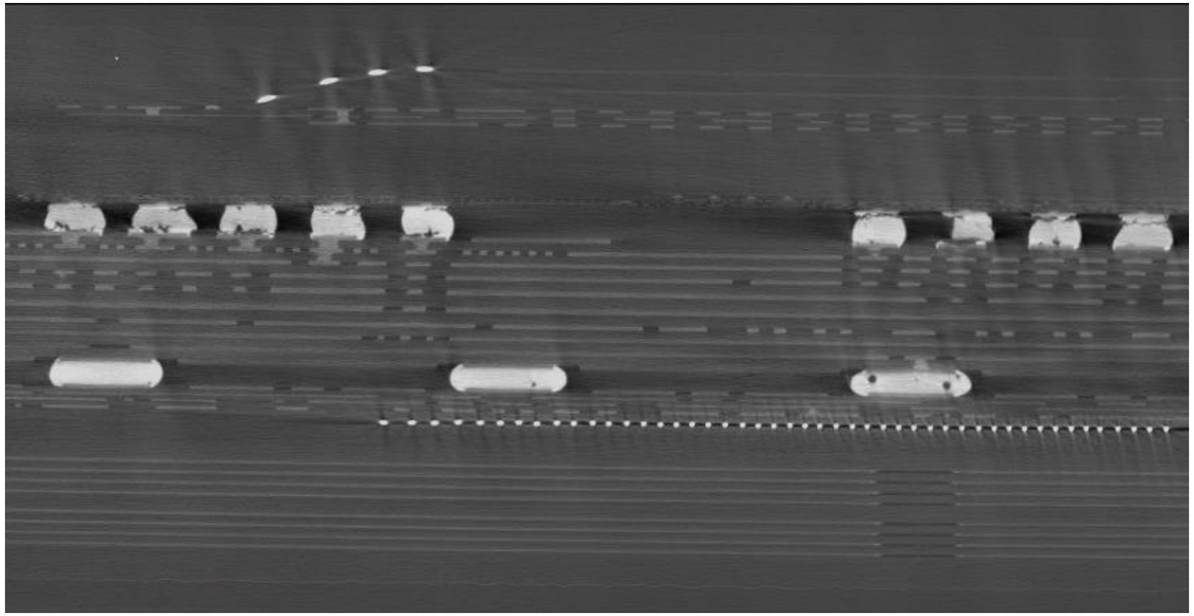
Smartphone A12 Control Board

Recovery of Resolution at a Large FOV

Digitally Zoomed-In Large Field of View Image



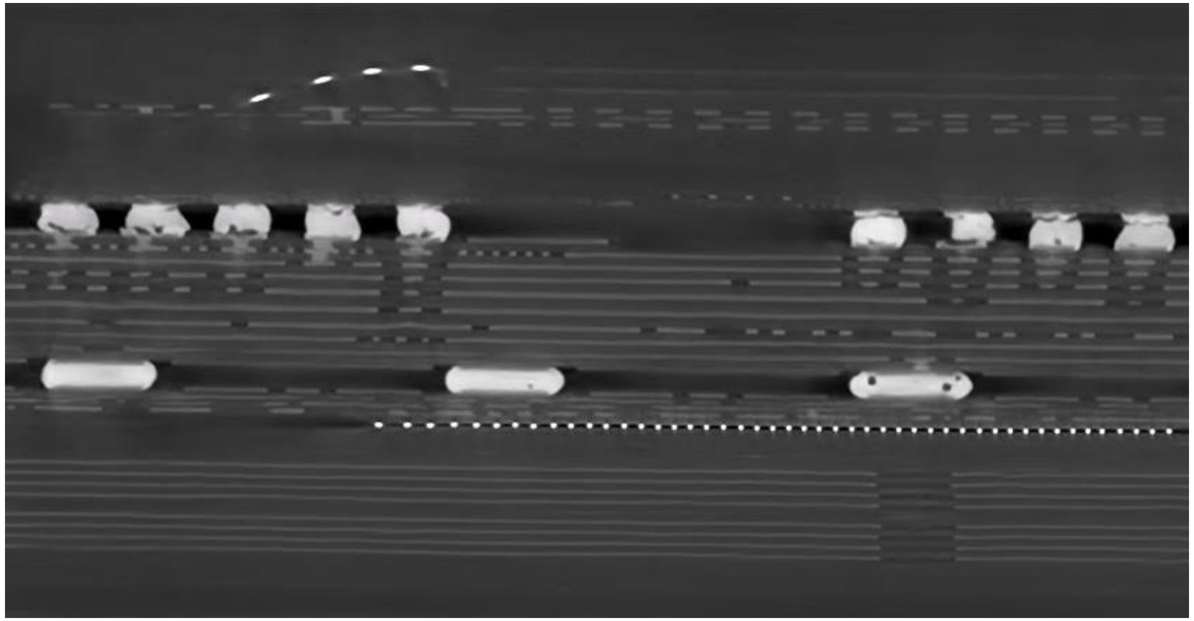
High Resolution Scan



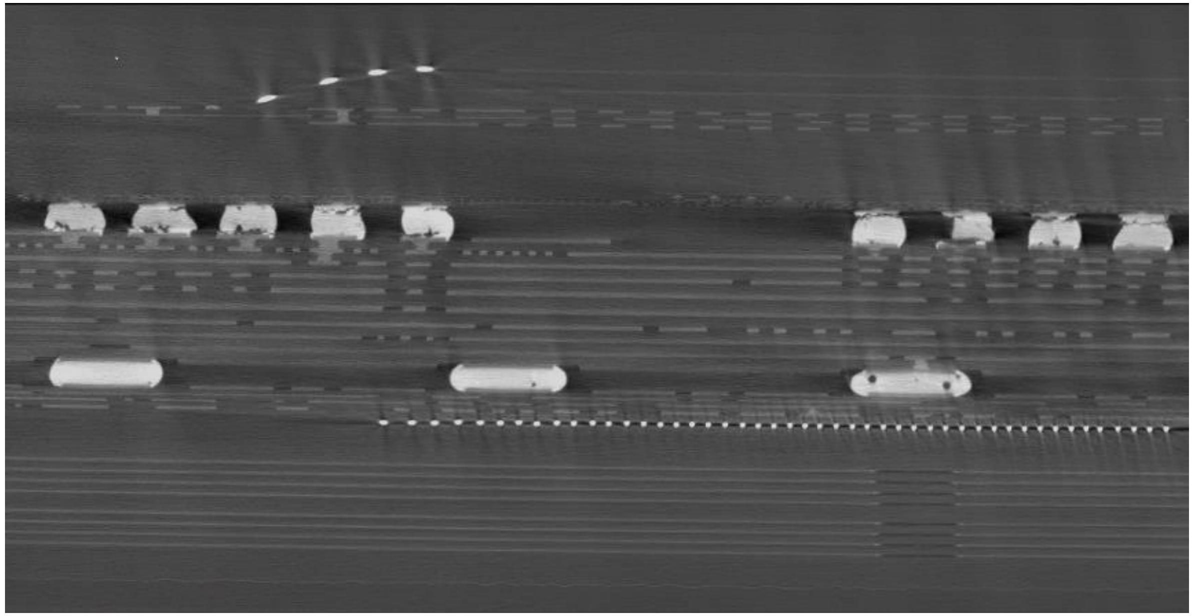
Smartphone A12 Control Board

Recovery of Resolution at a Large FOV

AI Resolution Recovered



High Resolution Scan



Conclusion

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- AI subsets machine learning and deep learning are seen across many aspect of microscopy, from sample prep to image analysis
- One key area that benefits from deep learning is X-ray CT reconstruction
- Deep Learning can be used to improve both throughput and quality of reconstructed data
- Deep learning can also be used in “super resolution” imaging, significantly reducing time required for collection of high resolution data
- **As long as used sensibly, AI can be a powerful tool in microscopy for improving speed, quality and automation.**

Seeing beyond