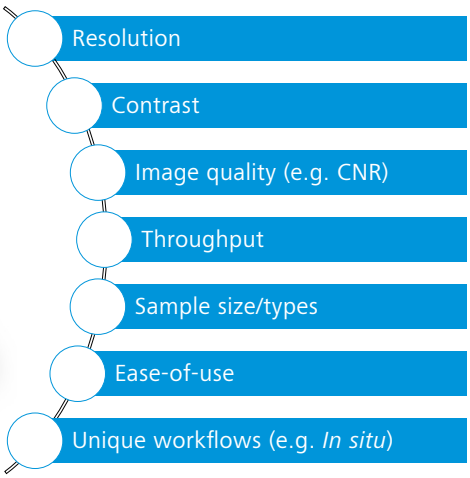
Technology to Enhance your ZEISS 3D X-ray Microscope

ZEISS Advanced Reconstruction Toolbox

To obtain useful 3D volumetric data from X-ray microscopy, 2D projections first need to be interpreted and combined using tomographic image reconstruction algorithms. Such reconstruction technologies typically have certain requirements, assumptions, advantages, and drawbacks that make them specifically well-suited to particular applications. Many different techniques are available that enable incremental performance to be extracted from datasets but may not be universally applicable across all sample classes, applications, or usage modes. The Advanced Reconstruction Toolbox (ART) from ZEISS is aimed at making these techniques available to increase the performance of 3D X-ray microscopes in their specific applications and use cases. The performance improvements that can be achieved with ART can be in terms of throughput, image quality, field of view, and ease of use. This toolbox acts as a platform to launch the next series of ground-breaking innovations from ZEISS X-ray Microscopy.

ART for ZEISS X-ray Microscopes



ART Benefits over Traditional FDK

Optimize each step in the production of actionable information

For 3D X-ray microtomography, these steps typically consist of sample mounting, scan setup, 2D-projection image acquisition, 2D to 3D image reconstruction, image post-processing and segmentation, and final analysis. In repetitive workflows (where many similar samples are run sequentially and image processing and analysis workflows are well understood), the slowest step is image acquisition and subsequent reconstruction. Even in academic environments where ROI is less of a concern, but where optimization of system usage should be considered, *in situ* analyses can require very high absolute temporal resolutions when performing 4D (time-resolved) scanning. Beyond this requirement, the analysis of subtle chemical or compositional differences, which may only exhibit very slight greyscale or textural contrasts, requires extremely low noise levels for accurate segmentation and classification. This means that even when acquisition time is less of a concern, image quality may require the use of advanced reconstruction technologies.

To reconstruct a 3D volume from a series of sequentially acquired 2D X-ray projections, traditionally FDK (Feldkamp-Davis-Kress algorithm) filtered back projection in cone beam CT geometry reconstruction is used. This technique works well with many views, however, relies on the assumption that the data is “well sampled” and does not contain significant noise.

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Seeing beyond

These assumptions are frequently broken in the interests of improving throughput by reducing total tomography acquisition time or for difficult-to-image samples or when pushing the boundaries of system capabilities, leading to excessive noise in the reconstructed image. This, in turn, leads to errors in segmentation and any resulting analysis of the data.

Unique ZEISS ART offerings leverage AI and a deep understanding of both X-ray physics and customer applications to solve some of the hardest imaging challenges in new and innovative ways.

DeepScout: resolution recovery at full field of view for access to both fine details and contextual views never before possible

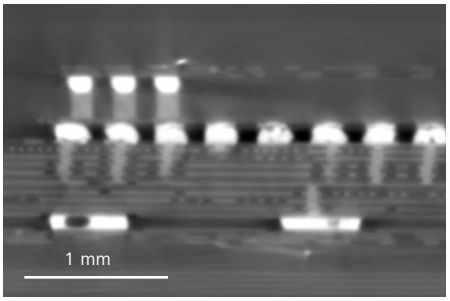
DeepRecon Pro: submicron resolution with resolution at a distance that is 10X faster or shows significantly improved image quality across diverse sample types

PhaseEvolve: enhanced image contrast for low-medium (low-Z) density samples with improved segmentation

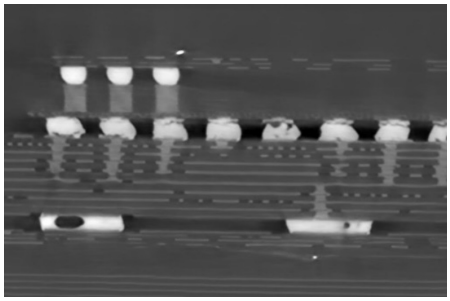
Materials Aware Reconstruction Solution (MARS): artifact reduction for improved image quality, especially for dense, high-Z materials next to light materials, e.g., metal implants in bone

OptiRecon: statistical iterative reconstruction enabling reduced sampling artifacts for 4X faster throughput or better image quality

These technologies significantly improve the performance of X-ray microscopes and CT platforms for materials science, biosciences, geoscience, semiconductor and electronics, industrial quality and control, metals, additive manufacturing, and other fields.

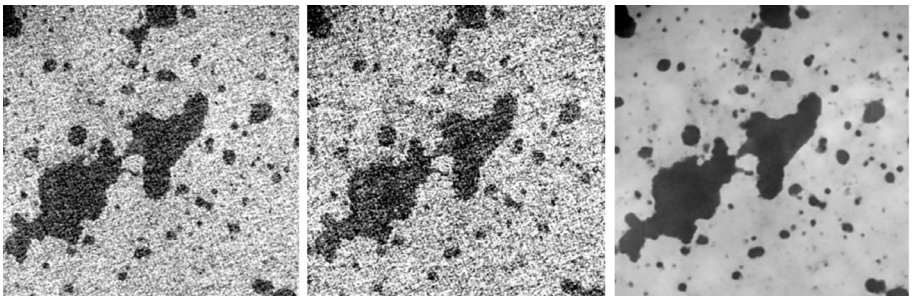


Standard resolution – 10 µm/voxel

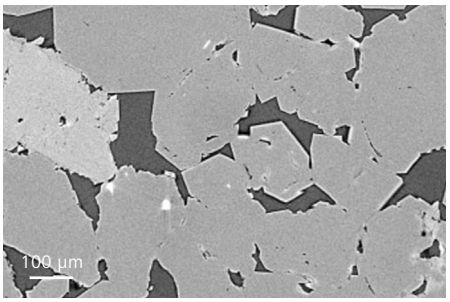


DeepScout recovered resolution – 2.1 µm/voxel

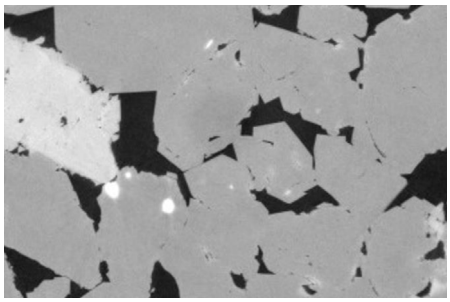
FDK (N_p = 720) **FDK** (N_p = 360) **DeepRecon** (N_p = 360)



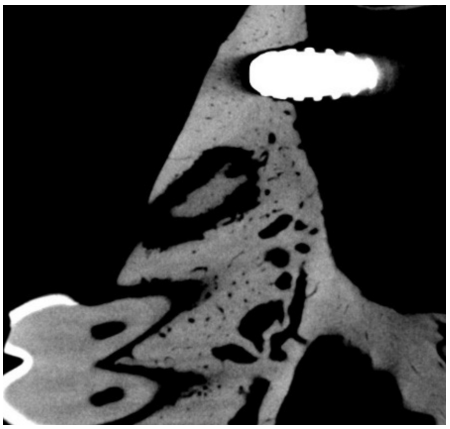
DeepRecon Pro (aluminum casting) – superior image quality with less noise in half the number of projections



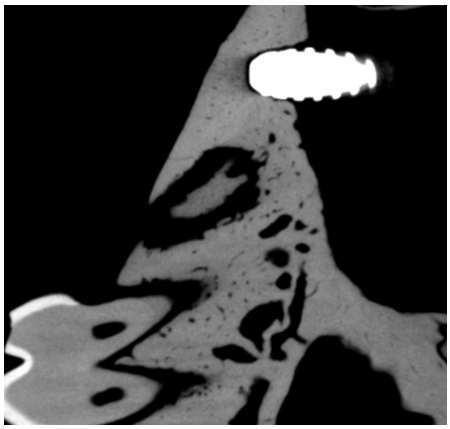
Berea sandstone without PhaseEvolve



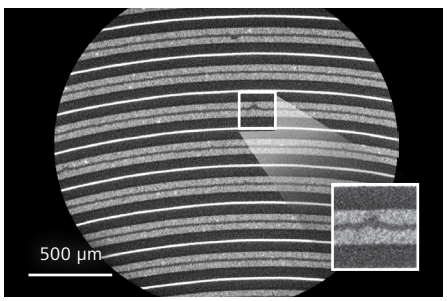
Berea sandstone with PhaseEvolve



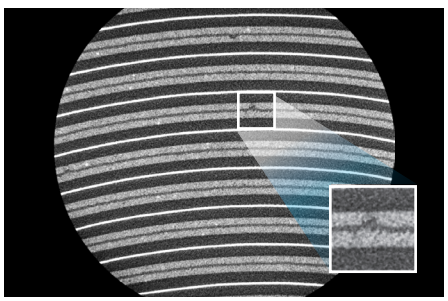
Without MARS – metal implant in bone



With MARS – metal implant in bone



Standard reconstruction – 18650 battery, 6000 projections



OptiRecon – 18650 battery, 1500 projections 4X throughput improvement with good image quality

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