



Technical Procedure: Phase Contrast Imaging

1 Abstract

This document describes the basic procedures to acquire phase contrast images with the ZEISS Xradia Versa family of 3D X-ray microscopes.

2 Overview

The optimization of data acquisition parameters to highlight phase contrast is different from imaging in the normal absorption mode. The quality of propagation-based phase contrast images depends on source energy, pixel size, and both source and detector positions. Other factors, such as resolution and signal to noise ratio, can additionally affect the quality of phase contrast in 3D reconstructed slices. This document provides a discussion of imaging parameters and presents a basic procedure to help users acquire good phase contrast images.

3 Procedure

3.1 Sample Preparation Procedure

Phase contrast is typically used for low-Z materials such as biological specimen or polymer materials where there is a distinct difference in refractive indices between regions. It is most advantageous on smaller samples since high magnification objectives can be used to enhance the quality of phase contrast and limit possible noise of images.

Specimen should be securely mounted with a standard sample holder. Phase contrast will only occur at distinct boundaries between materials with different refractive indices.

3.2 Imaging Procedure

Please refer to your instruments user's guide for information on the basic scan setup.

1. Center the feature on the rotation axis.
2. Switch to the desired objective (voxel sizes smaller than $\sim 3 \mu\text{m}$
3. Remove any source filters, if in place.
4. Set the source voltage to a low value, 40 kV is typical.
5. Set the initial source and detector distances for typical absorption imaging. This usually means having the source and detector close to the sample.
6. Acquire a single image with sufficiently high counts to see the specimen.

If transmission is less than 30%, phase contrast will be limited by the material thickness. Trim down the sample if possible – relatively high transmission at low kV is usually required to acquire high quality phase contrast images.

7. Adjust the source/detector distance for phase contrast

Move both the source and detector away from the sample in appropriate proportions. For example, if the initial source distance is -25 mm and detector distance is 7 mm, move the source to -50 mm and detector to 14 mm.

8. Acquire another single image with sufficiently high counts to see the specimen.

Note that the exposure time will need to be increased from what was previously used, to account for the increased distance between the source and detector. If the distance between source and detector has doubled the acquisition time will need to be increased by a factor of 4 to obtain the same number of counts.

9. Compare images.

A comparison between a typical absorption image and phase contrast image is shown in Figure 1. The edges of all features, including very small features are clearly enhanced in the phase contrast image. The sample shown is epoxy inside of a plastic tube. With the phase contrast enhanced image the interface of the air voids in the both the epoxy and the plastic tube are greatly improved.

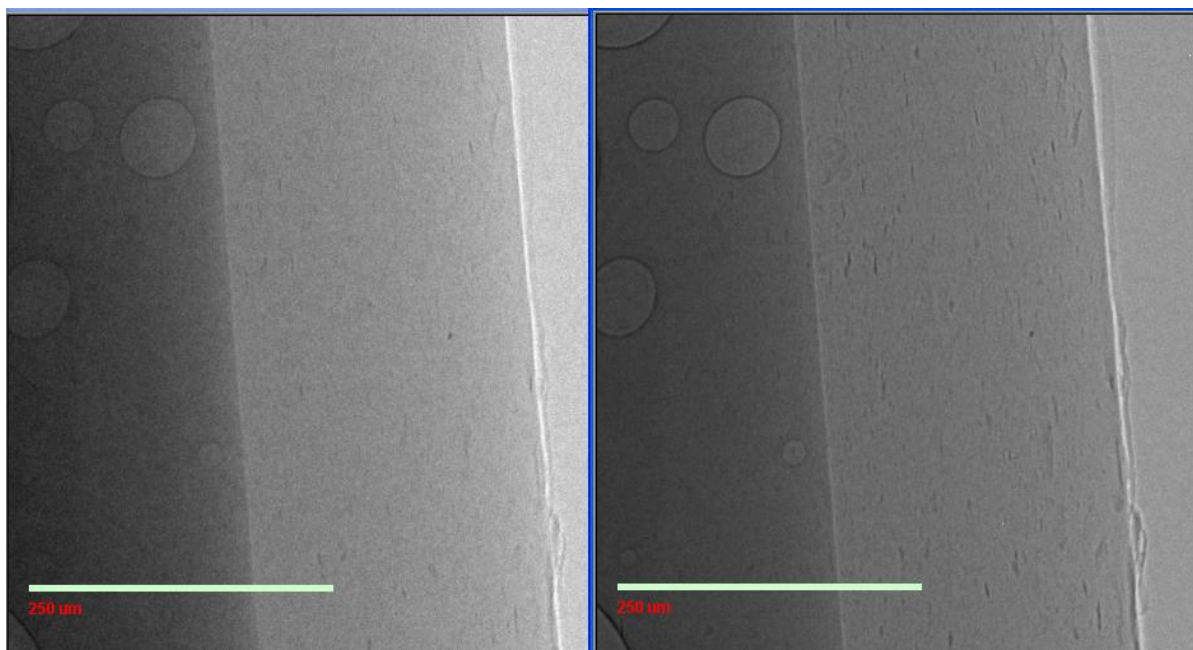


Figure 1: Comparison of a 2D projection image acquired with absorption contrast (left) and with enhanced phase contrast (right). 40 kV/4W and 20X (1 μ m pixel) were used to acquire both images. (Left): the source and detector distances are -25 mm and 7 mm, respectively. (Right): the source and detector distances are -75 mm and 21 mm, respectively

10. Final positioning of source/detector

The phase contrast effects may be further enhanced by increasing the distances between the source and detector. The user can adjust the source and detector distances to fine-tune the phase contrast effects, while maintaining the same ratio of source-to-sample to sample-to-detector distances.

Note for Xradia MicroXCT or Xradia 410 Versa users: To maintain high resolution with 20X and 40X objectives it is suggested to keep the ratio of detector to source distances at least 1:5. For example, if the detector is originally positioned at 10 mm the source should be positioned at 50 mm. To increase the phase contrast effect the detector may be moved to 20 mm with the source positioned at 100 mm in this case.

11. Set source power and exposure time

The larger distance between source and detector employed during phase contrast imaging will mean that x-ray flux is lower. A longer scan than normally used for absorption contrast imaging will usually be required. It's recommended to use maximum power for any kV.

12. Set up and run the recipe acquisition.

3.3 Reconstruction Procedure

Please refer to your instruments user's guide for recommended reconstruction settings. No additional considerations are required for reconstruction of images exhibiting phase contrast.

3.4 Data Visualization Procedure

Open the reconstructed .txm file for visualization, per standard procedures. Figure 2 below shows a comparison of a 3D reconstructed slice acquired by the absorption contrast mode (left) and phase contrast mode (right). The edges of the features appear sharper in the phase contrast image than in the absorption contrast mode.

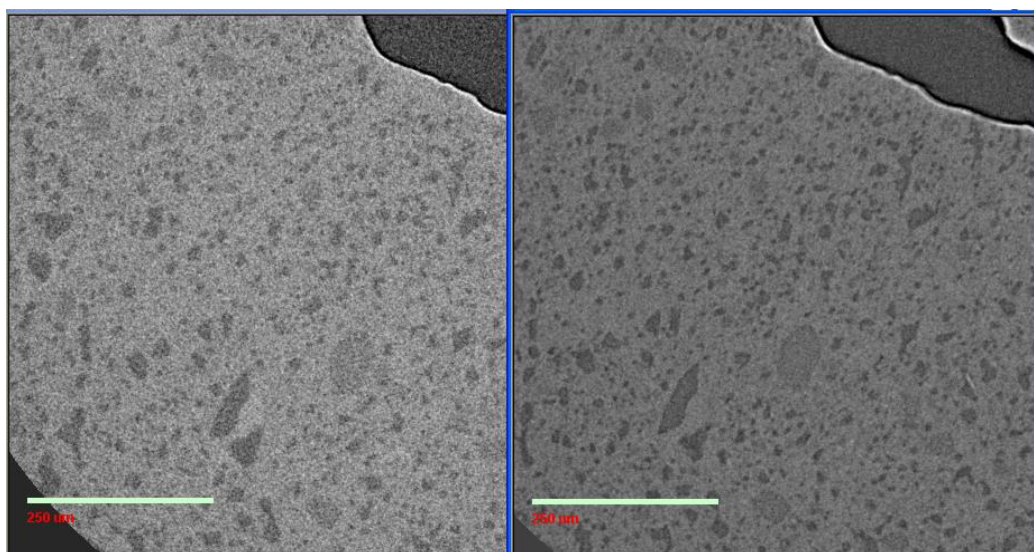


Figure 2: Comparison of a 3D reconstructed slice acquired by the absorption contrast mode (left) and phase contrast mode (right).



4 Summary

This document has described a procedure for enhancing the phase contrast effect for 3D imaging on the ZEISS Xradia Versa family of 3D X-ray microscopes. Using the phase contrast imaging mode may help to enhance the visibility of features which are difficult to distinguish utilizing standard absorption imaging techniques.