

**Stony Brook University
The Graduate School**

Doctoral Defense Announcement

Abstract

Phase Contrast Microscopy with Soft and Hard X-rays Using a Segmented Detector

By

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Scanning x-ray microscopes and microprobes are unique tools for the nanoscale investigation of specimens from the biological, environmental, medical, materials and other fields of sciences. In the soft x-ray range (below 1 keV photon energy), thus far they concentrate on studying chemical speciation of light elements by x-ray absorption near-edge structure (XANES) measurements. In the hard x-ray range (multi-keV), the main focus lies on trace element mapping by x-ray fluorescence.

Phase contrast provides a complementary contrast mechanism to absorption and fluorescence. In the soft x-ray range, it can help reduce the radiation dose imposed on the specimen by imaging below an absorption edge where absorption is low, but appreciable phase resonances occur. For harder x-rays, phase contrast allows the imaging of light elements which absorb very weakly at those photon energies. Therefore it provides a means to map the ultrastructure of biological specimens and put trace elements into their cellular context. In particular, there is a strong demand for *quantitative* measurements of ultrastructure to obtain traceelement concentrations rather than absolute amounts.

A segmented detector can be used to image the phase of the specimen in a scanning microscope or microprobe. This is done by measuring the redistribution of intensity in the detector plane caused by phase gradients in the specimen. This thesis work describes the application of a segmented detector in the soft x-ray range, and its further advancement for the use with hard x-rays. Differential phase contrast, obtained from simple difference images of opposing detector segments, is easy to obtain even in realtime and is useful for a qualitative overview of specimen phase. Furthermore, we describe the application of a Fourier filtering algorithm to obtain quantitative maps of specimen amplitude and phase, from which the specimen mass can be inferred. Software for inspection and quantitative analysis of x-ray microscopy data is also presented.

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Program: Physics

Dissertation Advisor: Prof. Chris Jacobsen