PhD Thesis Title: 'Phase Imaging using Focusing Polycapillary Optics'

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ABSTRACT:

The interaction of X-rays with soft tissues in diagnostic energy range can be described by Compton scattering and by the complex refractive index, which together characterize the attenuation properties of the tissue and the phase imparted to X-rays passing through it. Many soft tissues exhibit extremely similar attenuation, so that their discrimination using conventional radiography, which generates contrast in an image through differential attenuation, is challenging. However, these tissues will impart phase differences significantly greater than attenuation differences to the X-rays passing through them, so that phase-contrast imaging techniques can enable their discrimination.

A major limitation to the widespread adoption of phase-contrast techniques is that phase contrast requires significant spatial coherence of the X-ray beam, which in turn requires specialized sources. For tabletop sources, this often requires a small (usually in the range of 10-50 micron) X-rays source.

In this work, polycapillary optics were employed to create a small secondary source from a large spot rotating anode. Polycapillary optics consist of arrays of small hollow glass tubes through which X-rays can be guided by total internal reflection from the tube walls. By tapering the tubes to guide the X-rays to a point, they can be focused to a small spot which can be used as a secondary source.

The polycapillary optic was first aligned with the X-rays source. The spot size was measured using a computed radiography image plate. Images were taken at a variety of optic-to-object and object-to-detector distances and phase-contrast edge enhancement was observed. Conventional absorption images were also acquired at a small object-to detector distances for comparison. Background division was performed to remove strong non-uniformity due to the optics. Differential phase contrast reconstruction demonstrates promising preliminary results.

The thesis is divided into six chapters. The second chapter describes the limitations of conventional imaging methods and benefits of the phase imaging. Chapter three covers different types of X-ray photon interactions with matter. Chapter four describes the experimental set-up and different types of images acquired, along with

their analysis. Chapter five summarizes the findings in this project and describes future work as well.

Key Words
Phase Imaging, edge-enhancement, propagation-based, polycapillary optics, and Phase retrieval.

References to author publications that relate specifically to the dissertation:

- **Sajid Bashir**, Dr. Carolyn MacDonald, et al. Phase Imaging using focused polycapillary optics. Proc. SPIE 9209, Advances in Computational Methods for X-Ray Optics III, 920913 (5 September 2014); doi:10.1117/12.2062889
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- Jonathan C. Petruccelli**, Sajid Bashir**, et al. Computational techniques in propagation-based x-ray phase imaging, Proc. SPIE 9209, Advances in Computational Methods for X-Ray Optics III, 92090P (17 September 2014); doi:10.1117/12.2062917
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