Design and Characterization of a Phase Contrast x-ray CT System

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Phase contrast x-ray imaging has recently attracted wide research interest, as it offers the possibility to exploit different contrast mechanisms than conventional absorption imaging, with the potential for higher quality images or more available information as a result. This work details design and construction of an experimental grating-interferometer-based differential phase contrast computed tomography (DPC-CT) imaging system, presents measurements of performance, and compares this new imaging technique with conventional absorption imaging. Details of the fabrication of the specialized x-ray phase and absorption gratings are also provided. This system is unique in that makes use of a conventional rotating-anode x-ray tube, unlike previous designs which were based upon stationary anode x-ray tubes or synchrotron sources.

The imaging system described here enables simultaneous reconstruction of electron density, effective atomic number, attenuation coefficient, and small-angle scatter density with data acquired from a single scan. It is theoretically shown and experimentally verified that DPC-CT imaging allows imaging of electron density at high spatial resolution with a much less severe dose penalty compared with conventional absorption imaging. Improved object visibility using electron density imaging is demonstrated with CNR measurements in physical phantoms and comparisons of reconstructions of breast tissue samples. The ability to directly image both electron density and effective atomic number provides a truly quantitative imaging technique and accuracy of the technique is shown using phantoms and potential applications are demonstrated using breast tissue samples. A new reconstruction algorithm which allows a doubling of the diameter of the scanning field of view, a potential enabling technology for eventual clinical use, is also demonstrated.