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X-ray grating interferometry design for the 4D GRAPH-X system

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Abstract

The 4D GRAPH-X (Dynamic GRAting-based PHase contrast x-ray imaging) project aims at developing a prototype of an x-ray grating-based phase-contrast imaging scanner in a laboratory setting, which is based on the Moirè single-shot acquisition method in order to be optimized for analysing moving objects (in the specific case, a dynamic thorax phantom), that could evolve into a suitable tool for biomedical applications although it can be extended to other application fields. When designing an x-ray Talbot-Lau interferometer, high visibility and sensitivity are two important figures of merit, strictly related to the performance of the system in obtaining high quality phase contrast and dark-field images. Wave field simulations are performed to optimize the setup specifications and construct a high-resolution and high-sensitivity imaging system. In this work, the design of a dynamic imaging setup using a conventional milli-focus x-ray source is presented. Optimization by wave front simulations leads to a symmetric configuration with 5.25 μm pitch at third Talbot order and 45 keV design energy. The simulated visibility is about 22%. Results from GATE based Monte Carlo simulations show a 19% transmission percentage of the incoming beam into the detector after passing through all the gratings and the sample. Such results are promising in view of building a system optimized for dynamic imaging.

Keywords: x-ray phase contrast imaging, talbot-lau grating interferometer, dynamic imaging, wavefront simulation

(Some figures may appear in colour only in the online journal)

1. Introduction

Exploiting x-rays as an imaging modality requires a deep understanding of their interaction with matter. The imaging principle is based on analyzing x-rays that have passed through the object of interest and using this information to derive its material properties. The different kinds of interaction mechanisms of x-rays with matter yield specific and complementary information about the material properties of the object. In wave optics, the interaction of x-rays with matter is described by the refraction index ($n = 1 - \delta + i\beta$), whose imaginary (β) and real (δ) parts are related to the attenuation and the phase shift of x-rays, respectively. It is important to point out that

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