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Prototype design of a high sensitive phase-contrast computed tomography at 54.3keV X-ray

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1. Introduction

Grating based X-ray imaging is well known as an efficient system to get differential phase contrast image at a laboratory X-ray source. Since the differential phase contrast imaging measures phase shift as well as conventional absorption signal, it has the potential of considerably increased contrast [1-3]. Over the last few years, most of the grating based X-ray imaging has been used up to X-ray energies below 30keV. Recently, however, a higher X-ray energy region is required for most clinical and industrial nondestructive testing applications, and several studies have proceeded to setup grating interferometer for high X-ray energy [4-6]. In this study, a prototype for a food inspection system with a high sensitive phase-contrast computed tomography was designed.

2. Methods and Results

2.1 Grating design

The scheme in Fig. 1 shows the principle of tomography imaging with a Talbot-Lau grating interferometer. A source grating or absorption grating G0 maintains the spatial coherence properties even for the extended focal spot of the X-ray source, and a phase grating G1 make phase shift from wave front. The propagation of G1 results in a periodic intensity distribution in the plane of an analyzer grating G2. In this system, the analyzer grating G2 positioned in the third fractional Talbot plane behind G1, so the sensitivity is higher than the positioning G2 in the first fractional Talbot plane.

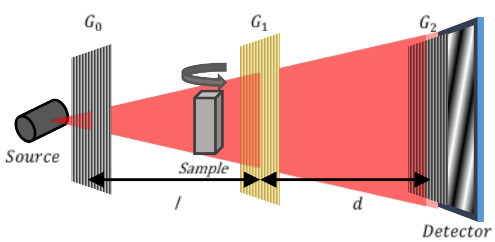

Fig. 1. Scheme of the Talbot-Lau grating interferometer

Gratings were fabricated periodic one-dimension. Fig. 2 shows fabricated three gratings. The height of G0 and G2 were built high enough to absorb high X-ray energy. In this high aspect ratio, a shadow artifact should be considered for industrialization, because the shadow artifact reduces active area. So, the G0 and the G2 were bent to reduce shadow artifact. Fig. 3 shows the bending holder for G0 and G2 gratings. The curvature was considered to match the configuration of our system.

Fig. 2. Gratings for Talbot-Lau interferometer

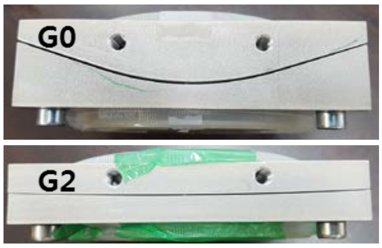

Fig. 3. Bending design to reduce shadow artifact

The period of G0, G1 and G2 gratings are 4.8μm, 2.4μm and 4.8μm, respectively. G1 is a $\pi/2$ phase shifting phase grating, and the equal periods of the G0 and G2 gratings imply a symmetric geometry. In this system, the distance l and d are set to 757mm. The symmetric geometry and the Talbot order of 3 rather than 1 are main focusing to design high sensitive Talbot-Lau grating interferometer in the proper system size for the industrialization. The patterning of the gratings was performed by Microworks GmbH.

2.2 System design

The 3D drawing in Fig. 4 shows prototype of a high sensitive phase-contrast computed tomography system. The total length of this system is around 2,000mm. And the sample mount is transferable to adjust spatial resolution. This Talbot-Lau grating interferometer is operated with a laboratory source and flat panel CMOS detector. The X-ray source (Spellman Co.) is the effective focal spot of 1mm diameter, and operated at 120kVp, 4mA, and additional Al filtration 10T. The resulting X-ray spectrum had an effective energy of about 54.3keV. The X-ray detector was adopted flat panel CMOS detector (PerkinElmer Co.), and the scintillator is CsI600μm.

Fig. 4. (up) 3D drawing and (bottom) the prototype design of the high sensitive phase-contrast computed tomography system

3. Conclusions

In this study, we designed prototype of the high sensitive phase-contrast computed tomography system at 54.3keV effective X-ray energy. The Talbot order of 3 and symmetric geometry in the restricted system size is optimized configuration for high sensitive and compact size as well. The imaging analysis and suitability for the food inspection system will be proceeded in the future.

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