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Talbot Optics Installation on Soft X-ray Projection Microscopy

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1 Introduction

Up to now, we have developed soft X-ray projection microscopy system with the correction technique to improve blurred projection images due to Fresnel diffraction. The iteration procedure was applied to biological samples and their successful corrections were achieved for the soft X-rays in the range of 700eV–1keV. To extend the application of projection microscopy, we tried to incorporate Talbot optics into projection microscopy to obtain phase information that cannot be accessible by normal projection microscopy. First we examined the coherency of soft X-ray region at BL11A.[1] In this study considering the coherency, we installed Talbot optics into the soft X-ray projection microscopy system and obtained preliminary results.

2 Experiment

Talbot effect is self-imaging effect to make the intensity distribution due to the grating period at a certain distance. Furthermore, it can extract the phase information by shifting the grating fringe with a certain phase interval. We installed a grating and a nano-positioning stage into the current soft X-ray projection microscopy system. The set up is shown in Fig.1. The pinhole of 1μm or 2μm diameter was utilized as an imaginary light source. The grating with 2μm or 4μm interval was put after the pinhole with the distance determined by Talbot optics. The sample can be moved within the distance of 4mm between the grating and the CCD image sensor, which enables the magnification of images. The projection of this microscope is effective, and the sample is magnified 40 – 76 times depending on the sample position. The grating, newly developed by Silson Ltd, has 5mm x 5mm imaging area with the uniform height (700 μm) and width (2μm or 4μm intervals) of Au lattices. Grating images are shown in Fig.2 with a visible light microscope image and a soft X-ray (1keV) image. Nano-positioning stage produced by Sigma Tech Co., Ltd, has a 10nm feedback positioning control, and it is ideal to control phase shift of the grating. Talbot effect was adjusted by the grating interval and the distance between the grating and the sample.

Figure 3(a) shows the observation example of slice sample of a human hair. Sample tissue was magnified 165 times and enlarged to fit the illuminated area. The medulla, a central part of hair, was observed at the center. The soft X-ray was 1keV and the pinhole was 1μm diameter. The grating was shifted perpendicular to the optical axis with 0.4μm interval. The phase distribution was extracted by the analysis of a set of grating phases shifted images. The result is shown in Fig.3(b). The cortex and medulla have different phase change. The medulla represents complicated structure and its lower right part and the upper left part seem to have the different phase orientation. We are continuing the improvement of the analysis procedure.

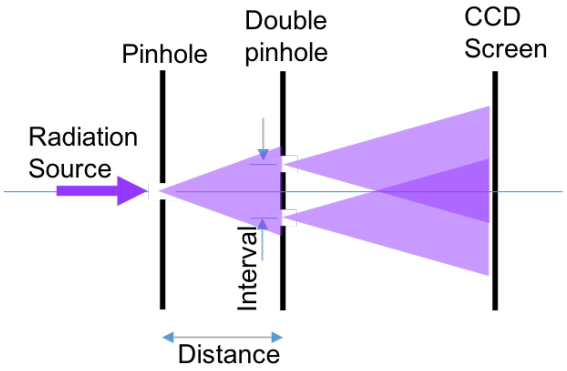
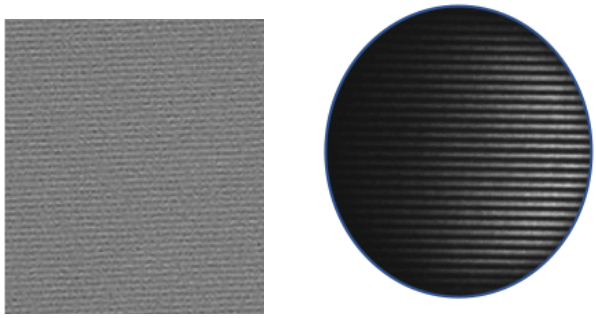
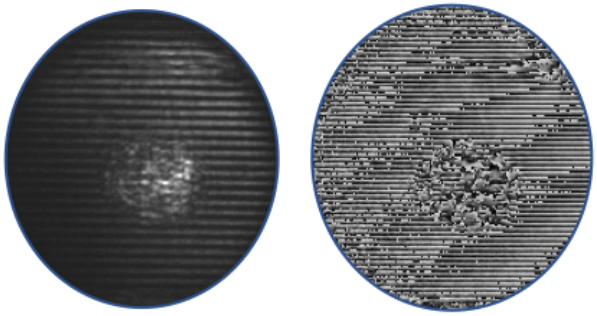


Fig.1 : Set up of Talbo optics into the soft X ray projection microscopy.



(a) Optical microscope (b) Soft-X ray microscope

Fig.2 : New graing for imaging (2μm interval).



(a) Observation Image (b) Phase Image

Fig.3 : Observation of human hair slice sample.

References

[1] T. Shiina et al., PF Activity Report 2017 #35 (2018). http://pfwww.kek.jp/acr/2017pdf/u_reports/pf17b0296.pdf

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