X-ray Phase-Contrast Imaging Technique Based on Multilens Interferometer

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The laser like properties of synchrotron beams enabled to develop in-line or paraxial schemes of X-ray interferometry such as classical Young’s double slit experiment or phase contrast imaging with grating interferometer [1-3]. Recently, we proposed the multilens interferometer consisting of a multiple set of parallel arrays of identical planar refractive lenses [4-6]. Under coherent X-ray illumination each lens in the interferometer generates a diffraction-limited beam that is focused at some distance. Then, due to overlapping such coherent beams, the interference field, which can be described by Talbot imaging formalism, is produced. This simple way to create an interference pattern opens up new opportunities for development of X-ray phase-contrast imaging techniques.

The phase object placed in front of the interferometer (Fig. 1(a)) leads to some distortion in the phase structure of the incident beam, which significantly affect the interference pattern. Thus, it is possible to extract comprehensive information about the sample structure from the resulting interference pattern. The high sensitivity of the interference pattern to distortions of the wave front is confirmed by our experimental results and computer simulation based on wave optic equations. However, as in the case of a conventional grating interferometer, the phase shift caused by the sample is integrated over one period of the interferometer, which leads to a deterioration in the spatial resolution.

On the other hand, the sample can be accommodated in the focal plane of the lenses (Fig. 1(b)). Knowing that the multilens system generates a set of diffraction limited (up to tens of nanometers) focal spots with a period up to tens of microns, it can be considered as an analog of a grating interferometer with extremely small gaps, which provides a very thin region of integration of the phase shift that a sample can cause. Moreover, unlike grating interferometers, the multilens interferometer can be used in a hard X-ray region (>30keV), while the manufacturing of thick micron-pitch grating interferometer is problematic. The accuracy of the phase determination depends on the resolution of the detector only, and the spatial resolution is determined by the size of the diffraction-limited focal spots created by the interferometer.

Proposed phase-contrast imaging technique based on X-ray multilens interferometer will allows studying natural and advanced man-made nanoscale materials such as selforganized biological systems, photonic crystals and nanoelectronics materials.

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