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X-ray Talbot Interferometry Using a Laser Compton Scattering X-ray Source

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A laser Compton scattering (LCS) photon source utilizes a combination of high-energy electron accelerator and a laser to produce high-energy photons. By changing the electron beam energy, the laser wavelength and the collision angle, an LCS photon source can be tuned to generate hard X-rays [1]. Around the beam center the LCS generated X-rays is quasi-monochromatic [2]. This beam characteristic is suitable for an X-ray Talbot interferometer (XTI) to generate high Moiré fringe visibility and perform with high sensitivity in detecting X-ray differential phase shifts [3].

Here we report on the first results of X-ray Talbot interferometry using the linac-based LCS X-ray source developed at AIST where the maximum energy of X-rays is tunable between 10 to 40 keV [2]. The source size which was determined by the laser spot size was not small enough to generate spatially coherent X-rays for a Talbot interferometer located ~ 2 m downstream from the collision point, hence a source grating with a period of 22.7 µm and an opening of 7.9 µm was used to improve the spatial coherence. In this manner an X-ray Talbot-Lau interferometer (XTLI) configuration was implemented. The π/2 phase grating and the analyzer grating have periods 4.36 µm and 5.4 µm, respectively.

The LCS X-ray source was tuned to generate a maximum X-ray energy of 27 keV and a mean energy of 25 keV. The XTLI was constructed with design energy of 25 keV. The simulation results show that, with this design energy, Moiré fringe visibility is constant within ± 1.5 cm from the center of the beam at the detector position. The obtained Moiré fringe within 2 cm field of view of the XTLI using an image plate with exposure time of 30 minutes has a visibility of 18% showing the feasibility of the LCS X-ray source for X-ray Talbot interferometry. The standard deviation of the X-ray differential phase shift measured via a 3-step fringe scan was 0.4 µrad. This value could be improved if the Moiré fringe visibility and the X-ray flux would be increased. One way to improve the visibility is to reduce the background bremsstrahlung radiation due to the dark current of the linac. Improvements in the LCS set-up are in progress to achieve these goals.

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