論文の内容の要旨

Dissertation Abstract

Development of Stroboscopic X-ray Talbot Interferometry Using Laboratory and Synchrotron X-ray Sources （実験室および放射光 X 線源を用いたストロボスコピック Talbot 干渉計の開発）

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X-ray phase imaging and quantitative X-ray phase tomography have become established techniques to differentiate the constituent parts of soft materials that give poor contrast in conventional X-ray absorption imaging. Prospectively, dynamic X-ray phase imaging has many applications in materials science, biology, and medicine; however, the realization of quantitative X-ray phase imaging with a good temporal and spatial resolution remains a challenge. In this work, a time-resolved, quantitative X-ray phase imaging technique without sacrificing the spatial resolution for the visualization of periodic processes in soft materials has been developed. The technique is called Stroboscopic X-ray Talbot Interferometry, which is the combination of a stroboscopic imaging technique with X-ray Talbot interferometry. X-ray phase imaging was performed via the fringe scanning technique, in which the moiré image during each step of the amplitude grating G2 scan was obtained by repeatedly acquiring an image of a specific phase of motion in which the object was captured "frozen in time", hence overcoming the dynamic imaging constraint in X-ray photon flux without sacrificing the spatial resolution. Two stroboscopic X-ray Talbot interferometry techniques have been developed using polychromatic X-ray sources: 1) using a Talbot interferometer, white beam synchrotron radiation and an X-ray image detector based on a high-speed CMOS camera, and 2) using a Talbot-Lau interferometer utilizing a rotating anode X-ray generator, a mechanical X-ray chopper and an X-ray image detector based on a CCD-camera. Since X-ray Talbot interferometry employs transmission gratings, the constraint in photon flux was additionally overcome by using polychromatic X-ray sources. In order to achieve the goal of imaging the object "frozen in time", a condition for the imaging duty cycle that must be achieved by a stroboscopic X-ray Talbot interferometer was given. By utilizing white beam synchrotron radiation in conjunction with a high-speed CMOS camera, stroboscopic X-ray phase imaging with very small duty cycle of 1/25000 and the

microsecond temporal resolution was achieved in contrast with the previously reported millisecond temporal resolution using non-stroboscopic X-ray Talbot interferometry. Another merit of stroboscopic X-ray Talbot interferometry is that even low-flux X-rays could be used. In combination with a Talbot-Lau interferometer, a conventional laboratory X-ray generators of incoherent, polychromatic, and cone-beam X-rays was utilized. Looking forward to the realization of stroboscopic X-ray Talbot interferometry for future clinical and industrial applications, stroboscopic X-ray Talbot interferometry technique using an X-ray Talbot-Lau interferometer incorporated with a simple mechanical X-ray chopper and synchronizer system, a demonstration of stroboscopic X-ray Talbot interferometry was achieved using a chopper duty cycle of 1/40 and the millisecond temporal resolution was achieved.