17p-C13-14

Stroboscopic Talbot Interferometry for X-ray Phase Imaging of Periodic Processes in Soft Materials

Univ. of Tokyo[1], Tohoku Univ.[2],

[D]Margie P. Olbinado[1,2] , Patrik Vagovic[2], Wataru Yashiro[2], Atsushi Momose[2]

E-mail: olbinado@mail.tagen.tohoku.ac.jp

X-ray phase imaging is an established tool to visualize the constituent parts of soft materials that typically give poor contrast in X-ray absorption imaging.[1)] 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. Propagation-based x-ray phase contrast imaging with μm spatial resolution to visualize gun shock loading,[2)] liquid-jet-flow dynamics[3)] and high-tension bar loading,[4)] at ps, ns and μs temporal resolutions, respectively; as well as of biological functions of insects[5-8)] have been obtained using synchrotron radiation. Although useful for visual inspection, quantitative analysis is not easily possible from the obtained single phase-contrast data. Quantitative x-ray phase imaging without complicated algorithms is achievable with interferometry. To avoid the acquisition of several images for phase retrieval during fringe scanning, the Fourier transform method has been employed in X-ray Talbot interferometry. A temporal resolution of 1 ms/ frame and 1 s/ tomogram[9,10)] were obtained, however, the required few-pixel fringe spacing gave a spatial resolution of a few tens of μm.

We report a time-resolved X-ray phase imaging that is applicable for visualizing periodic processes in soft materials. A stroboscopic technique that overcomes the constraint in photon flux by repeatedly illuminating the object at a specific phase of its motion to capture an image of the object “frozen in time” was combined with X-ray Talbot interferometry in order to achieve: 1) quantitative X-ray phase imaging, 2) μs temporal resolution, and 3) μm spatial resolution by using the fringe scanning technique. By utilizing a Talbot interferometer using white synchrotron radiation and a high-speed camera, a 3 μs temporal resolution was achieved.

1) A. Momose: Jpn. J. Appl. Phys. 44 (2005) 6355.
2) Y. Wang, X. Liu, K. Im, W. Lee, J. Wang, K. Fezzaa, D. L. S. Hung, and J. R. Winkelman: Nat. Phys. 4 (2008) 305.
3) S. N. Luo, B. J. Jensen, D. E. Hooks, K. Fezzaa, K. J. Ramos, J. D. Yeager K. Kwiatkowski, and T. Shimada: Rev. Sci. Instrum. 83 (2012) 073903.
4) M. Hudspeth, B. Claus, S. Dubelman, J. Black, A. Mondal, N. Parab, C. Funnell, F. Hai, M. L. Qi, K. Fezzaa, S. N. Luo, and W. Chen: Rev. Sci. Instrum. 84 (2013) 025102.
5) M. W. Westneat, O. Betz, R. W. Blob, K. Fezzaa, W. James Cooper and W. K. Lee: Science 299 (2003) 558.
6) M. W. Westneat, J. J. Socha and W.K. Lee: Annu. Rev. Physiol. 70 (2008) 119.
7) O. Betz, A. Rack, C. Schmitt, A. Ershov, A. Dieterich, L. Korner, D. Haas and T. Baumbach: Synchrotron Radiation News 21 [5] (2008) 34.
8) D. A. Schwyn, R. Mokso, S. M. Walker, M. Doube, M. Wicklein, G. K. Taylor, M. Stampanoni and H. G. Krapp: Synchrotron Radiation News 26 [2] (2013) 4.
9) A. Momose, W. Yashiro, H. Maikusa, and Y. Takeda: Opt. Express 17 [15] (2009) 12540.
10) A. Momose, W. Yashiro, S. Harasse, and H. Kuwabara: Opt. Express 19 [9] (2011) 8423.

© 2013 年　応用物理学会