The development of pink-beam 4D phase CT to observe the laser drilling into the poly(methyl methacrylate)

JASRI [1], Tohoku Univ. [2], ◦(P)Karol Vegso[1], Yanlin Wu[2], Hidekazu Takano[2], Masato Hoshino[1], Atsushi Momose[1,2]

E-mail: karol.vegso@spring8.or.jp

We report the development of pink-beam 4D (time-resolved) phase CT at BL28B2 at SPring-8 facility to observe fast phenomena related to the laser-induced drilling and engraving into the polymer. In our experimental configuration, the X-ray multilayer mirror was applied to filter out white synchrotron radiation and a resultant pink-beam with a mean energy of 25 keV and an energy bandwidth of 10 % was used for phase imaging by X-ray Talbot interferometer (XTI) [1]. The main purpose of pink-beam was reduction of radiation damage caused to samples and tailoring the spectrum of X-ray beam fit to XTI. The XTI was composed of a $\pi/2$ phase grating (G1) and an amplitude grating (G2) with a pitch of 5.3 μm with a spacing corresponding to the 1st fractional Talbot distance of 283 mm between them. 4D phase CT was performed with the continuous fringe scanning technique to record a movie of differential phase images. In the continuous fringe scanning technique, during 5 continuous sample rotations, G1 was continuously moved by a distance equal to the grating pitch (5.3 μm). In this study, we improved the time for recording differential phase images during 180° sample rotation from previously reported 2 s [2] to 1 s. The improved temporal resolution was achieved by increasing of frame rate of X-ray detector from 1000 fps to 2000 fps while the number of projections per 180° rotation was maintained at a value of 400 and field of view was decreased from 1536 x 512 to 1024 x 512 (H x V). The developed pink-beam 4D phase CT set-up with improved temporal resolution was applied to observe laser-induced drilling into the poly (methyl methacrylate) (PMMA).

We successfully visualized the bubbling phenomenon occurring during laser drilling into the PMMA where laser was operated in pulse mode (50 ns pulse width, 154 kHz repetition frequency). We successfully demonstrated that pink-beam 4D phase CT can be used to study laser drilling into the polymer. In the near future, we plan to visualize the laser ablation of carbon-fiber reinforced plastics by pink-beam 4D phase CT.

References

[1] A. Momose, H. Takano, M. Hoshino, W. Yashiro, and Y. Wu, SPIE Proc. 9967 (2016) 99671E

[2] A. Momose, H. Takano, M. Hoshino, Y. Wu, and K. Vegso, SPIE Proc. 10391 (2017) 103910Y