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Investigations on welding of fused silica using ultrafast double-pulse irradiation

Sizhu Wu[1], Dong Wu[1], Jian Xu[2], Koji Sugioka[1, 2], Katsumi Midorikawa[1]

[1] 理化学研究所 緑川レーザー物理工学研究室

[2] 理化学研究所 理研-SIOM 連携研究ユニット

E-mail: sizhuwu@riken.jp

Glass microwelding induced by an ultrafast laser has been drawing attention for applications such as optics, microelectromechanical systems, precision machinery, healthcare, and small satellites. Fused silica is a promising material for those applications due to its excellent electrical, chemical and especially optical properties. Recently, many groups have successfully demonstrated microwelding of fused silica using the ultrafast laser [1-2]. Meanwhile, we demonstrated for the first time that double-pulse irradiation of ultrafast laser pulses realized high efficiency microwelding of photostructurable glass [3]. The physical mechanism of glass microwelding by double-pulse irradiation has been further systematically investigated [4-5]. In this paper, we apply the ultrafast double-pulse irradiation technique for the fused silica microwelding.

The experimental setup is the same as that used for Foturanglass microwelding in previous studies [4-5]. Because of high melting point of fused silica, here we use an amplified femtosecond Er-fiber laser system (IMRA model FCPA μJewel D-1000) generates 457-fs pulses at a wavelength of 1045 nm with a repetition rate of 100 kHz. The substrates used were a commercially high-quality fused silica (Suprasil-P700). Figure 1 shows the optical microscope image of cross sections modified at different delay times with a pulse energy of 3.8 μJ. Figure 2 shows dependence of the modified depth on the delay time for three different pulse energies. We can see the delay time significantly affected the depth. The deepest depth of ~180.7 μm was obtained at the delay time of 0.5 ps and a pulse energy of 3.8 μJ. The depth drastically decreases beyond 5 ps and is almost saturated after 100 ps.

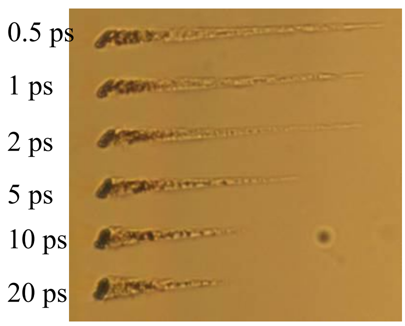

Fig.1 The optical microscope image of the depth

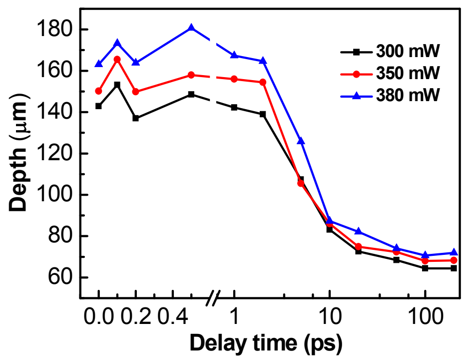

Fig.2 The depth as function of delay time

[1] T. Tamaki, *et al.*, *Jpn. J. Appl. Phys.*, **44**, L687 (2005). [2] D. Helie, *et al.*, *Appl. Opt.*, **51**, 2098 (2012). [3] K. Sugioka, *et al.*, *Opt. Lett.*, **36**, 2734 (2011). [4] S. Wu, *et al.*, *Opt. Express*, **20**, 28893 (2012). [5] S. Wu, *et al.*, *Opt. Express*, **21**, 24049 (2013).