Improvement of Fabrication Resolution in Two-photon Polymerization by GHz Burst Mode Femtosecond Laser

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In recent years, two-photon polymerization (TPP) has opened a new path towards fabricating high-resolution polymerized three-dimensional nanostructures for constructing functional microdevices [1]. Numerous research studies have shown that laser parameters and localized photoexcitation in the laser focal spot have a significant effect on the fabrication resolution of TPP [2]. Over the past decade, laser processing with GHz burst pulses of femtosecond (fs) pulses has been highly regarded for improving performance of laser-induced microfabrication [3]. This technique enables efficient laser-material interaction with multiple fs pulses at GHz repetition rates in burst pulses, which should be further investigated for different types of laser processing.

This study investigates the TPP of SU-8 using a green-wavelength (515 nm) GHz burst mode fs laser. We show superiority of the GHz burst mode over the conventional single-pulse mode for improving the fabrication resolution when fabricating SU-8 suspended polymerized lines. As Figure 1(a) shows, for the GHz burst mode laser processing with an intra-pulse number of P = 10 (10 pulses in a burst pulse), the polymerization threshold energy of intra-pulses is ~64% smaller than that of the single-pulse mode. The experimental results reveal that for the suspended polymerized lines with a length of ~20 µm, the TPP resolution in a plane perpendicular to the beam axis is slightly improved by ~9% using the GHz burst pulses. More importantly, the improvement of resolution along the beam axis is much more pronounced with a ~31% reduction (Figure 1(b)).

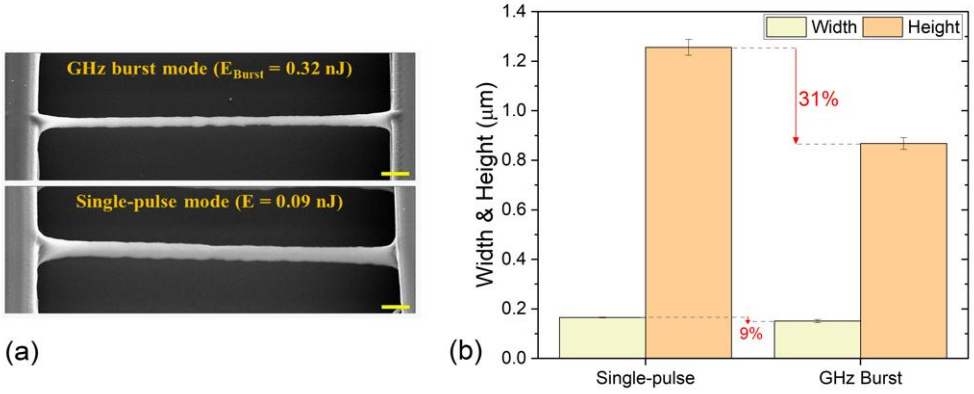

Figure 1: (a) SEM images (30° tilted view, scale bar: 1 µm) and (b) comparison of width and height of the suspended SU-8 polymerized lines fabricated by single-pulse mode and GHz burst mode (P = 10) laser processing at the polymerization threshold energies of 0.09 and 0.32 nJ, respectively.

References:

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