Top-down ablation of fused silica by BiBurst femtosecond laser

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Ultrafast lasers remain essential tools for processing transparent materials such as glasses. Classic top-down and bottom-up ablation techniques are the most established approaches for precision glass milling. The bottom-up technique is superior to the top-down approach in high milling rates due to the effective material removal mechanism. Here, glass is fractured into small particles during the ablation and is ejected opposite the beam entry side, avoiding laser beam shielding effects. However, this technique is unsuitable for milling non-transparent glasses and for 3D glass processing (processing from both sides). Hence, a slower top-down technique remains a more promising technique for such applications.

Fortunately, recent studies showed that milling rates of the top-down approach could be drastically improved by using MHz or GHz bursts [1]. Moreover, an increased milling rate was demonstrated for microprocessing of silicon with GHz bursts in MHz bursts (BiBurst mode) [2]. However, no studies were reported on glass ablation with femtosecond laser BiBursts.

In this study, we used a femtosecond laser (Carbide from Light Conversion) working in BiBurst mode to ablate fused silica glass. Ablated areas were evaluated using an optical profilometer. Removed material thickness, sidewall taper, and surface roughness Sa were measured. Results indicated a similar material-removing mechanism to a bottom-up technique by initiating glass cracking (see Figure 1), which significantly increased glass milling rates up to a few hundred mm^3 per minute.

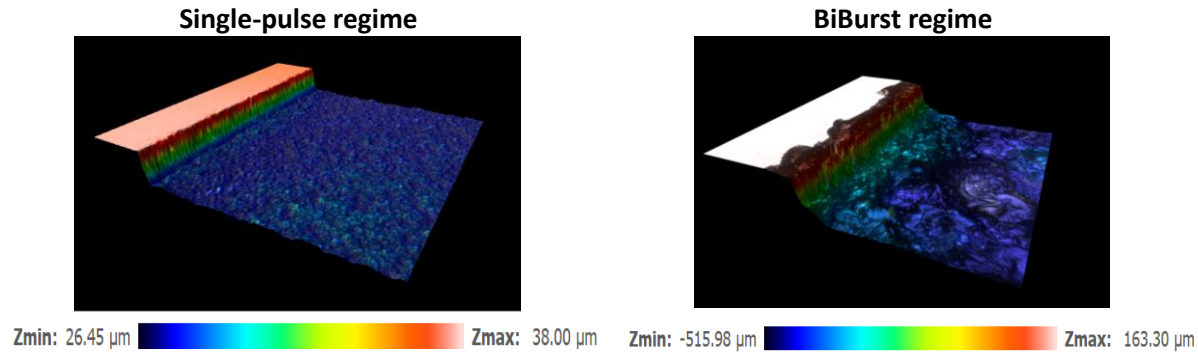

Figure 1: Topographies of milled cavities in single pulse (on the left) and BiBurst (on the right) modes.

References: [1] S. Schwarz, S. Rung, C. Esen, and R. Hellmann, Enhanced ablation efficiency using GHz bursts in micromachining fused silica, Optics Letters, vol. 46, pp. 282-285, (2021); [2] K. Obata, F. Caballero-Lucas, S. Kawabata, G. Miyaji, and K. Sugioka, GHz bursts in MHz burst (BiBurst) enabling high-speed femtosecond laser ablation of silicon due to prevention of air ionization, International Journal of Extreme Manufacturing, vol. 5, 025002, (2023).