High-efficient ultrashort pulse laser ablation in the long burst GHz pulse regime

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Ultrashort pulse lasers (USPL) have been established as a fascinating tool for micro processing and surface functionalization. However, the limited productivity and throughput represents the current bottleneck in the entry of USPL technology in real-life applications. A feasible method for increasing removal rates in USPL machining is burst mode laser operation by irradiating pulse trains of hundreds ultrashort sub pulses to the substrates. Recent studies revealed a significant potential to increase the ablation efficiency in USPL machining by using femtosecond laser pulses in long burst operation at GHz intra-burst pulse repetitions [1].
In this study, we present high-speed laser material removal in the GHz long burst laser regime. A hybrid fiber-seeded crystal-booster amplified laser source was combined for the first time with a polygon-mirror based scan system for ultrafast laser beam raster scanning. In addition, a state-of-the-art galvanometer scanner was applied to investigate a broad range of scan speeds between 2 m/s and 500 m/s. It will be shown that the removal efficiency on Stainless Steel (AISI 304) could be increased by a factor of 2.8 when using laser bursts with 1,300 intra-burst pulses instead of using single USPL pulses of optimum fluence. The highest removal efficiency was achieved at 10 m/s, steadily decreasing with faster laser beam moving speeds, Figure 1 (left). As another evaluation criterion, the machining quality was evaluated, Figure 1 (right). In addition to the influence of the intra-burst pulse number and scan speed on material ablation, the effect of burst repetition frequency and average laser power will be discussed. Finally, the results obtained will be compared with material removal in the nanosecond pulse regime to further enhance the understanding of long burst and GHz laser ablation.

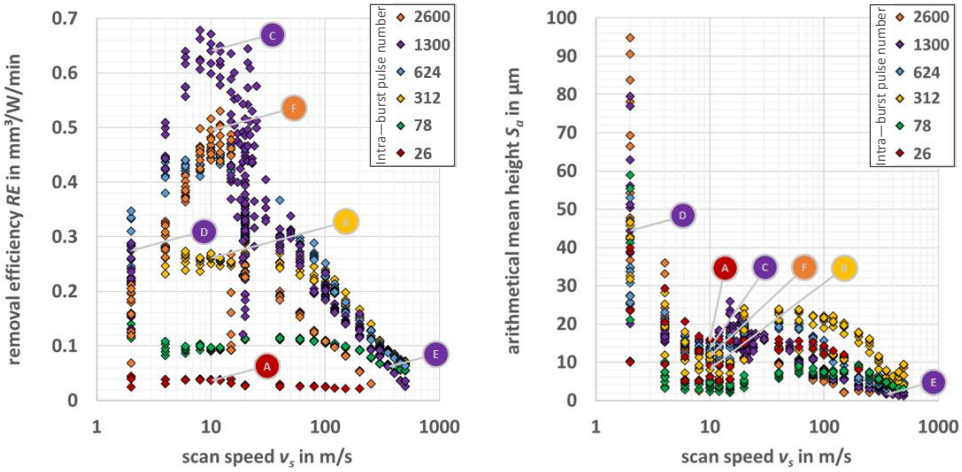

Figure 1: Removal efficiency and surface roughness in long burst and high-speed USPL machining of Stainless Steel. Laser processing parameters: 95 W average laser power, 470 fs pulse duration, 200 kHz burst repetition frequency, 1.3 GHz intra-burst pulse repetition frequency, between 26 and 2600 intra-burst pulses, between 2 m/s and 500 m/s scan speed. Same machining conditions are indicated (A-F).

References: [1] E. Audouard and E. Mottay: *High efficiency GHz laser processing with long bursts*. Int. J. Extrem. Manuf. 5 (2023) 015003