

Supplementary material

Highly-efficient laser ablation of copper by bursts of ultrashort tuneable (fs-ps) pulses

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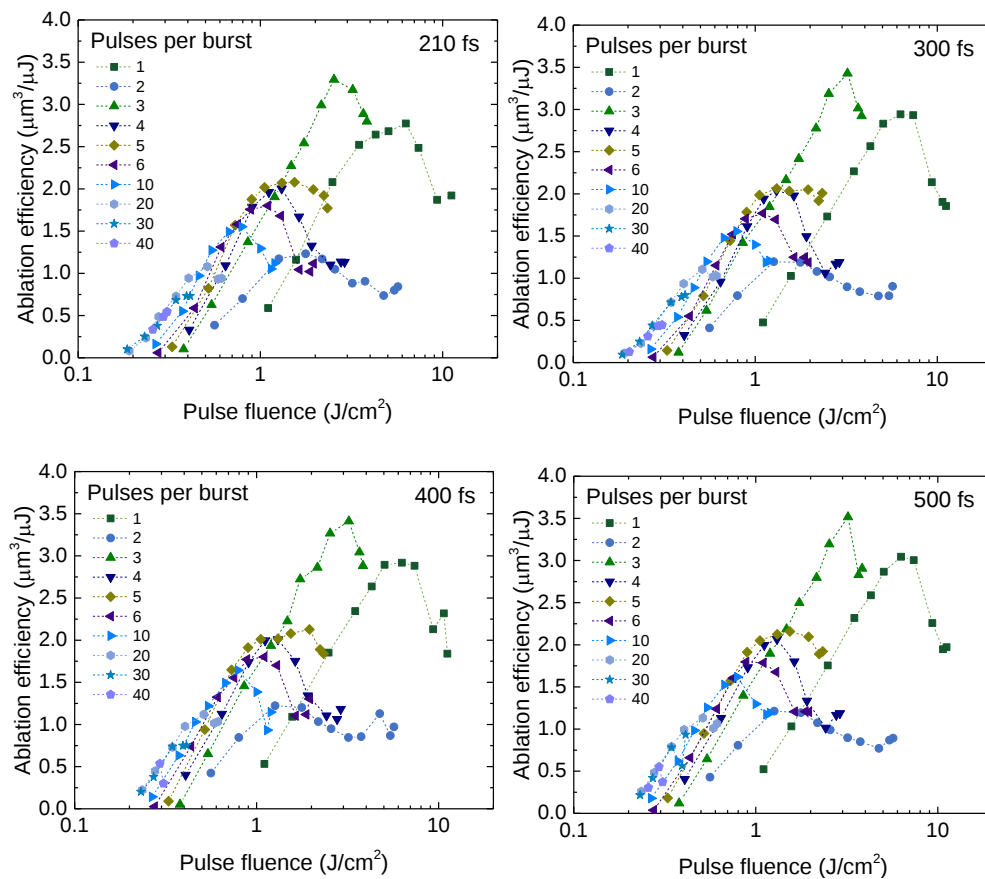
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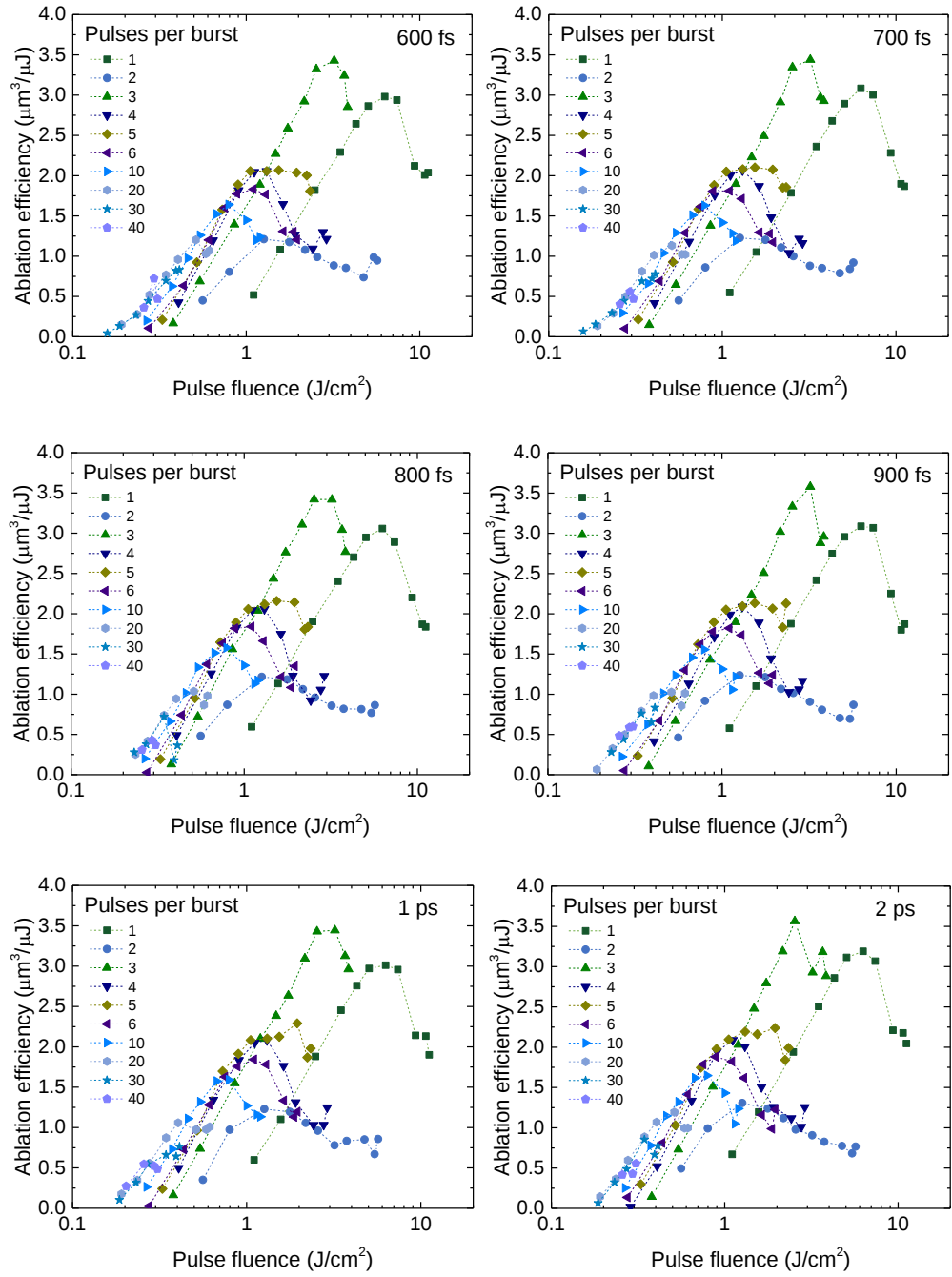
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Number of pulses per burst

The ablation efficiency has maxima at specific laser fluence values. The fluence values were found to be dependent on the pulse number in the burst, but almost independent on the pulse duration (Fig. 1). The highest efficiency was measured for 3 pulses in the burst for all pulse durations. The increase in the ablation efficiency comparing to the single-pulse regime was from 11 to 20 %, depending on pulse duration. The shift of the curves to lower fluence is evident with increasing the number of pulses in the burst.





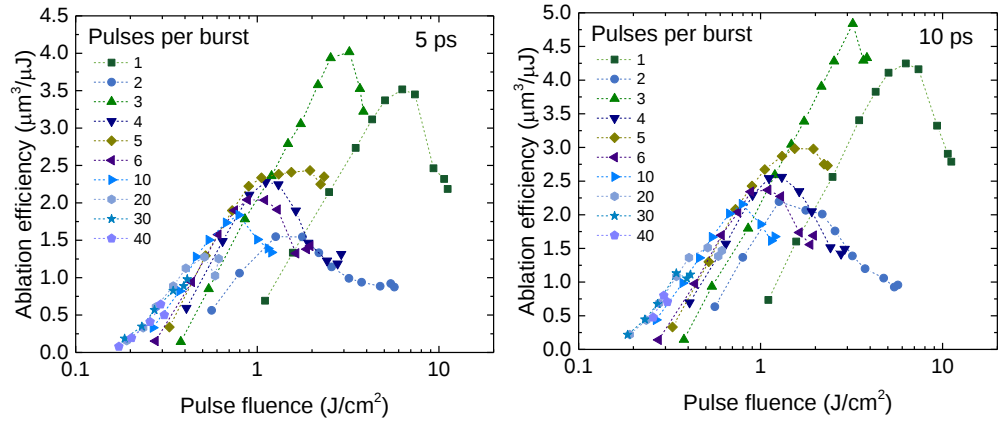
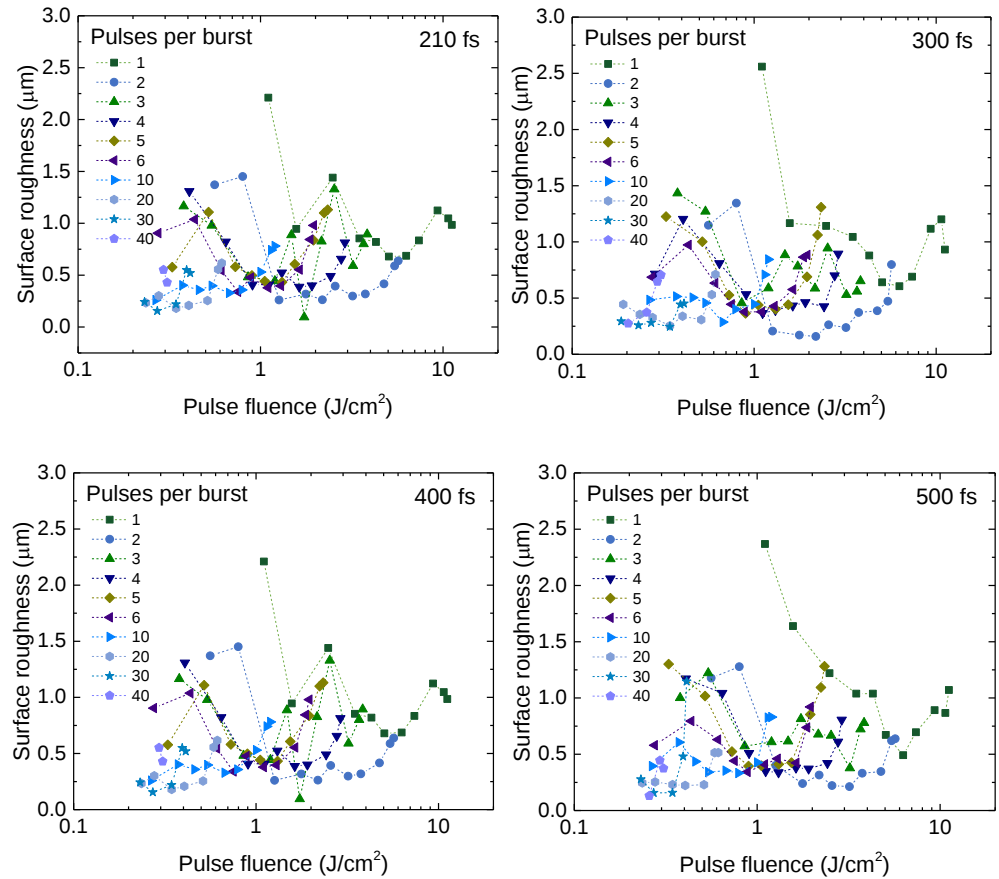
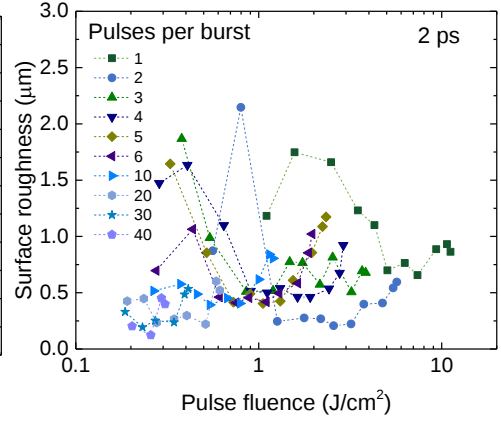
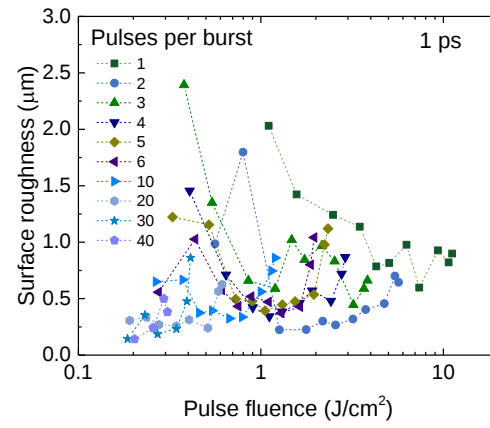
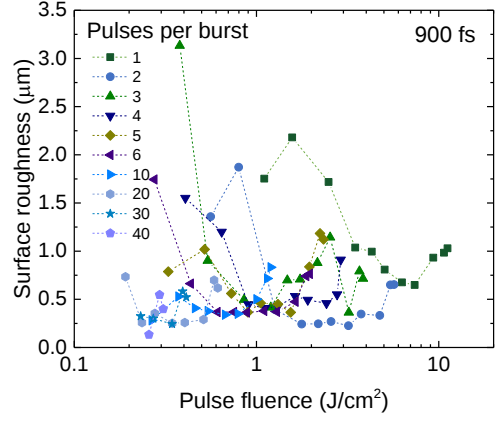
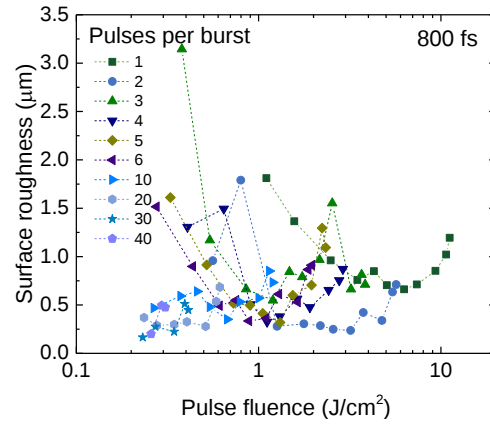
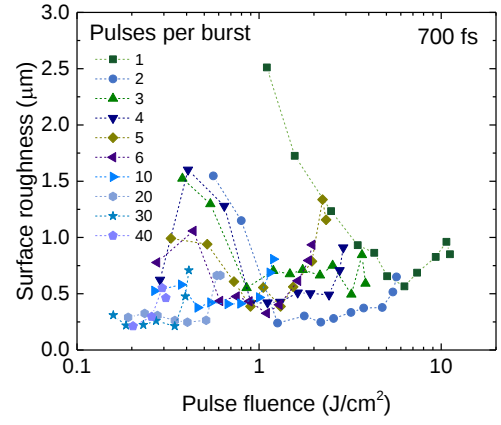
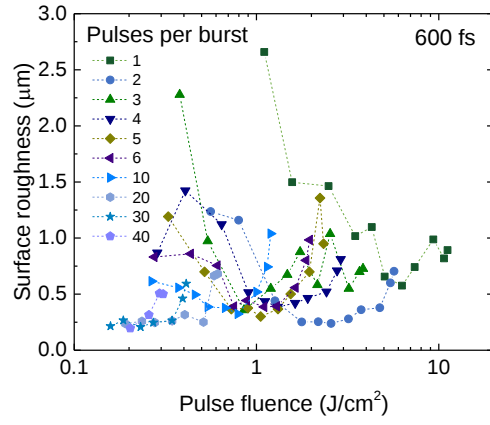


Fig. 1. Ablation efficiency versus peak pulse fluence for various numbers of pulses per burst and different pulse durations. The laser fluence was changed by increasing the beam size. The laser wavelength $\lambda = 1030$ nm, burst repetition rate $f_B = 300$ kHz, intra-burst repetition rate $f_P = 64.5$ MHz, beam scanning speed $v = 1$ m/s.

Surface roughness

The surface roughness on the bottom of the cavities was lowest at laser fluences in the same range, which was found for the highest ablation efficiency, of 1-3 J/cm² (Fig. 2).





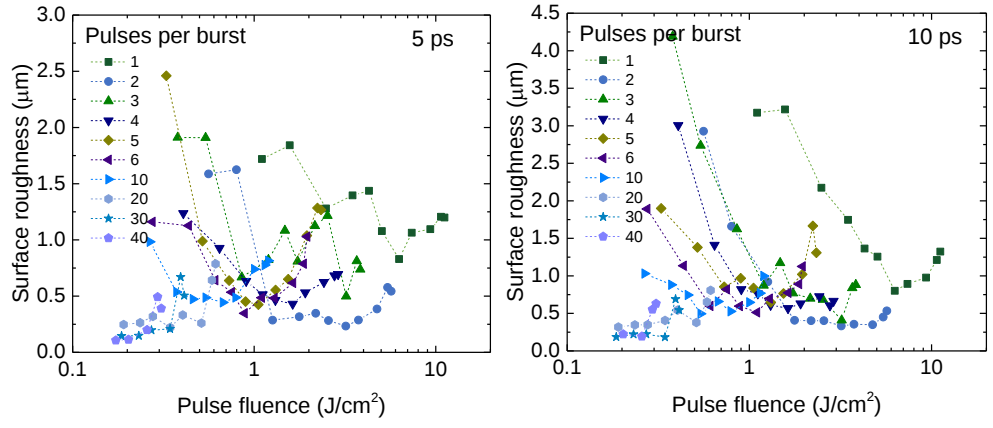


Fig. 2 Surface roughness on the bottom of the cavity versus peak pulse fluence for various numbers of pulses per burst and various pulse durations. The laser wavelength $\lambda = 1030$ nm, burst repetition rate $f_B = 300$ kHz, intra-burst repetition rate $f_p = 64.5$ MHz, beam scanning speed $v = 1$ m/s.