GHz burst mode laser ablation with fs laser pulses for efficient surface microfabrication

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Lasers providing ultrashort pulses are becoming widely used for multiple applications thanks to their extremely short pulse durations, which confine energy absorption to the processed zone and ensure a precise material ablation. However, challenges are encountered when high speeds for material removal are required. In this situation, the use of more powerful lasers for increasing ablation rates leads to undesired effects like shielding and collateral damage due to heat accumulation. In recent studies, GHz burst mode laser ablation has been proposed as a successful method to overcome this limitation by applying ablation cooling [1]. GHz bursts of ultrafast laser pulses can ablate the material before the residual heat induced by previous pulses diffuses away from the processed zone. At the same time, the ultrafast succession of pulses makes possible a reduction of the pulse energy needed for material ablation. Owing to that, increased ablation efficiencies have been reported [2]. Following this approach, we study the influence of laser irradiation parameters in burst mode laser ablation on the ablation efficiency. In this study, each burst contains multiple pulses happening at an ultrafast repetition rate of 5 GHz. Results shown in Figure 1 give evidence of the differences in ablation between GHz burst mode and conventional single pulse laser ablation. Specifically, the use of multiple pulses in one burst compared to irradiation with a single pulse resulted in a deeper and wider ablated crater, even the total accumulated energy was kept the same.

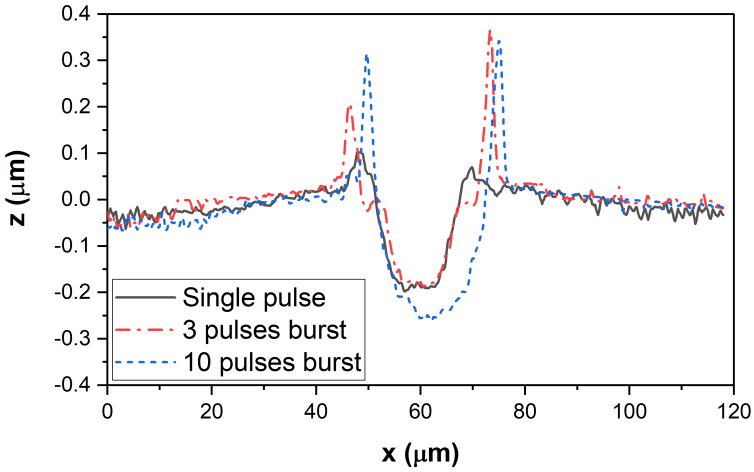

Figure 1 Profiles of the ablated spots on the surface of a crystalline silicon sample processed by 1028 nm femtosecond laser pulses in air. The continuous line shows the profile of the spot irradiated with one single pulse, while the discontinuous lines give the profiles for the spots processed with a burst containing 3 (red) and 10 (blue) pulses at a repetition rate of 5 GHz. Total pulse energy for the three cases was kept constant at 24 μJ.

[1] C. Kerse, et al, Ablation-cooled material removal with ultrafast bursts of pulses, Nature, vol. 537, (2016).
[2] K. Mishchik, et al, High-efficiency femtosecond ablation of silicon with GHz repetition rate laser source, Optics Letters, vol. 44, (2019).