Influence of the target temperature on femtosecond laser processing of silicon

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The effects of the initial target temperature on the femtosecond (fs) laser processing of solid targets have been addressed in some studies, with different features observed for diverse materials. For example, Mezera et al. showed that pre-heating polycarbonate lowers the laser fluence required to form some surface structures [1], whereas an increase in the fluence threshold for low spatial frequency surface structure was reported by Deng et al. for silicon [2] also observing an effect on the crystallinity of the produced surface structures [3].

Here we investigate the role of the initial target temperature on the ablation process of silicon induced by irradiation with 1030 nm, ~ 200 fs laser pulses in air, in a fluence range covering both the generation of laser induced surface structures (LIPSS) and the formation of deeper ablation craters.

The samples used in the experiment are pieces of intrinsic silicon, cut from a ≈400 m thick polished wafer with (100) crystalline orientation and resistivity greater than 200 Ω cm. The target is located on a heater in air at atmospheric pressure and irradiated by step-scanning of the laser beam; the laser beam is focused by a lens on the target surface producing shallow ablation craters decorated with laser-induced periodic surface structures (LIPSS), in an appropriate fluence range, or deeper ablation craters at higher fluence values. The variation of the fluence threshold with the target temperature is analyzed from room temperature to about 500 °C, also addressing the influence on the morphological features of the produced surface structures.

References:

[1] Marek Mezera, Joern Bonse, Gert-Willem R.B.E. Römer, Polymers. 11, 1947 (2019)
[2] G. Deng, G. Feng, K. Liu, S. Zhou, Applied Optics 53, 3004 (2014)
[3] G. Deng, G. Feng, K. Liu, S. Zhou, XX International Symposium on High-Power Laser Systems and Applications 2014, 9255, 955 (2015)