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# Ultra-short pulsed laser processing of sapphire

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Synthetic crystalline sapphire is hard, transparent and inert to most chemical etchants. It is a popular substrate for numerous applications in e.g. semiconductor industry, microfluidics, smartphones and watches. However, sapphire is challenging to machine with traditional techniques such as mechanical dicing. Tightly focusing a femto- or picosecond pulsed laser beam inside the bulk of sapphire amorphized a volume in and near the laser focus (diameter ~ 1 micrometer). This amorphized region can be selectively removed by chemical etching in a subsequent step, resulting in hollow volumes and structures [1]. For the technique to be fully exploited, several scientific challenges still need to be overcome. To address these challenges, we combined an experimental and a theoretical approach study and optimize this two-step method. Our numerical model allows simulation of the laser-material interaction during short pulsed laser processing of sapphire [2]. Physical phenomena included in the 2D and time-dependent model are the laser intensity distribution, free electron density, electron temperature and lattice temperature during and directly after the pulse. Simulation results show that avalanche ionization needs to be triggered for sapphire to absorb laser energy. Our experimental results show that the pulse energy and focus depth are the most dominant laser parameters. Further, the type of etchant used has a strong effect on the resulting structures, not only, in the bulk, but also on the surface of sapphire.

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