New insights into challenging physics of hydrodynamic melt removal at high-intensity nanosecond laser ablation of metals

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Ultradeep removal of metallic materials by high-intensity nanosecond laser pulses in plasma-mediated hydrodynamic regime is well known for the half of century. Multi-micrometer, almost sonic-speed ablation rates per nanosecond laser pulse durations, exceeding by one order of magnitude the few-micrometer near-surface heat affected zone, dense screening ablative plasma and (sub)microsecond-delayed directional sub-sonic expulsion of melt microdroplet fountains are highly promising in nanosecond-laser machining, but still challenging for theoretical explanation. Deep heating of metals by radiative (bremsstrahlung, recombination) and/or shock-wave energy transport were alternatively considered as the key fundamental phenomena, underlying the ultradeep nanosecond ablation process, with the auxiliary physical phenomena like laser peening or cracking in air or water ambients also essentially affecting the performance of the nanosecond-laser michomachining technology. The new experimental insights into this challenging multi-scale physics of hydrodynamic melt removal at high-intensity nanosecond laser ablation of metals are provided and discussed.