Propagation of laser-induced shock waves: hydrodynamics simulation in cylindrical geometry

Shepelev V V[1,@], Petrov Yu V[2], Inogamov N A[2], Zhakhovskii V V[3], Perov E A[4] and Fortova S V[1]

[1] Institute for Computer-Aided Design of the Russian Academy of Sciences, Vtoraya Brestskaya 19/18, Moscow 123056, Russia
[2] Landau Institute for Theoretical Physics of the Russian Academy of Sciences, Akademika Semenova 1a, Chernogolovka, Moscow Region 142432, Russia
[3] Dukhov Research Institute of Automatics (VNIIA), Sushchevskaya 22, Moscow 127055, Russia
[4] Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg 2, Moscow 125412, Russia

[@] vadim.aries@gmail.com

The problem of propagation and attenuation of a shock wave induced in a metal target by a single femtosecond laser pulse is considered. If the pulse power is sufficiently large, laser irradiation can induce a strong shock wave that causes residual plastic deformations in the near-surface layer of the metal target. The result of shock wave action may be a change in the strength properties of the target, an increase in resistance to fatigue loads, corrosion, and the formation of microcracks. Such effects are the basis of laser schock peening (LSP) technology.
The mode of wave propagation in the first tens of picoseconds changes from planar to hemispherical, which leads to its rapid attenuation. Laws of propagation and attenuation of a shock wave in a metal in two-dimunsional planar and three-dimensional axisymmetric geometries are investigated. The numerical algorithm is based on solving the Euler equations with the equation of state in the form of Mie-Gruneisen. The results of modeling are compared with molecular dynamic simulations. The shape and dimensions of the area of residual deformations capable of causing a hardening effect in the metal are obtained.