Deformation and fragmentation of liquid metal tin droplet irradiated by intense laser pulses

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The problem of interaction of a laser pulse with a droplet has attained practical interest during the development of extreme ultraviolet (EUV) sources used in the next-generation industrial lithography. It was found that irradiation of a tens-micrometer sized liquid metal tin droplet by two successive laser pulses produces plasma which emit photons in the EUV range. The first pulse (known as the "pre-pulse") serves to optimize the target by deforming or even fragmenting it. The second pulse (known as the "main pulse") heats the material to a high-temperature plasma state.

This computational study is devoted to analysis of the deformation and fragmentation mechanisms of a liquid metal tin droplet under the influence of short laser pre-pulses. Simulations demonstrates generation of a strong pressure wave propagating from the frontal side to the rear side of a droplet, caused by laser irradiation. Convergence of such a wave results in strong tensile stress and cavitation of material inside the central zone. Reflection of a wave from the rear surface lead to formation of a thin spall layer moving with a high velocity.

We also investigate the long-term evolution of the droplet, which strongly depends on surface tension. Molecular dynamic simulations reproduce a cross-like jets observed in experiments using linearly polarised laser irradiation. We found that such an oriented jets are formed as a result of angle-dependent loading, caused by the polarization of the laser pulse.