SIMULATION OF THE DIFFRACTION LIMITED GAUSSIAN AND VORTEX ILLUMINATIONS OF SUPPORTED METALLIC FILMS

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(Dated: May 31, 2017)

Nanoscale motion of film on dielectric substrate driven by energy absorption from a femtosecond laser pulse produces redistribution of mass of the film and results in formation of frozen surface structures [1-4] and shocks [5]. We consider the tight focused optical pulses of different radially distributed intensity from the Gaussian shape (when absorbed energy has a maximum in the center) to the shape corresponding to the vortex pulses (when absorbed energy has a minimum =0 in the center). Our approach combines two-temperature hydrodynamics codes together with molecular dynamics code. The molecular dynamics code is based on Voronoi decomposition of mass. The Monte-Carlo description of electron heat conductivity added to the molecular dynamics package allows us to include real values of large and thermally important conductivity of metals. Conductive heating and after that cooling of matter cause melting and later recrystallization of a film. We simulate dynamics of solids (film, substrate) together with hydrodynamics of liquid (film, substrate) separated by the first order phase transformation zones.

Our approach includes all underlying physical processes associated with laser-induced energy absorption, electron-ion energy exchange, thermal conduction, acoustic relaxation and hydrodynamic flows. Physical model is based on separation of “slow” and “fast” processes. Hybrid calculations use two-temperature hydrodynamics, scalable molecular-dynamics simulations, and a semi-analytical thin-shell model. These calculations provide accurate predictions of the final nanoscale solidified morphologies.

Simulations of femtosecond laser action on films is necessary because they are linked to a promising technologies. Among them are: processing thin-film transistors, scribing thin-film solar cells, ablative fabrication and light-induced forward transfer (LIFT)-printing of advanced plasmonic and dielectric nanophotonic metasurfaces and circuits. In comparison to subnanosecond laser pulses, the ultrashort ones are broadly used during such precise ablation, ensuring an ultimate spatial resolution.

ACKNOWLEDGMENTS

This research was supported by the Russian Science Foundation (grant no. 14-19-01599).

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