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Ultrashort elastic and plastic shock waves in nickel generated by femtosecond laser pulses NAIL INOGAMOV, Landau Institute for Theoretical Physics, BRIAN DEMASKE, VASILY ZHAKHOVSKY, University of South Florida, CARTER WHITE, Naval Research Laboratory, IVAN OLEYNIK, University of South Florida —

The structure and evolution of ultrashort shock waves generated by femtosecond laser pulses in thin nickel films were investigated by molecular dynamics and two-temperature hydrodynamics simulations. Ultrafast laser energy deposition results in the formation of a highly-pressurized 100-nm-thick layer below the surface of the film. Relaxation of the stress-confined state leads to the creation of a strong compression wave that later transforms into an ultrashort shock wave. Analysis of experimental data shows that such a shock wave, generated by low absorbed laser fluence, can exhibit a pure elastic structure despite an amplitude exceeding the conventional Hugoniot elastic limit. For absorbed fluences above $\sim 0.6\ \mathrm{J/cm^2}$, two independent processes of elastic and plastic wave breaking are observed with the elastic precursor appearing before formation of the plastic wave. It is found that the amplitude of the elastic precursor is almost independent of the absorbed fluence, but closely related to the pressure at the melting front. The decay rate of the plastic wave amplitude is much higher than that of the elastic wave, which may result in the complete disappearance of the plastic wave within the metal film.

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