

Surface dynamics of warm dense plasmas upon high-intensity laser irradiation investigated by grazing-incidence x-ray surface scattering

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Observing ultrafast laser-induced structural changes in nanoscale systems is essential for understanding the dynamics of intense light-matter interactions. For laser intensities on the order of 10^{14}W/cm^2 , highly-collisional plasmas are generated at and below the surface. Subsequent transport processes such as heat conduction, electron-ion thermalization, surface ablation and resolidification occur at picosecond and nanosecond time scales. Imaging methods, e.g. using x-ray free-electron lasers (XFEL), were hitherto unable to measure the depth-resolved sub-surface dynamics of laser-solid interactions with appropriate temporal and spatial resolution. Here we demonstrate picosecond grazing-incidence small-angle x-ray scattering (GISAXS) from laser-produced plasmas using XFEL pulses. Using multilayer (ML) samples, both the surface ablation and subsurface density dynamics are measured with nanometer depth resolution. Our experimental data challenges the state-of-the-art modeling of matter under extreme conditions and opens new perspectives for laser material processing and high-energy density science.

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