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Femtosecond laser ablation of aluminum in vacuum and air at high laser intensity

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Keywords:

Femtosecond laser ablation, aluminum, ablation rate, collisional absorption, collisionless absorption, early plasma.

Abstract

In this study, the ablation of aluminum by a near-infrared femtosecond laser pulse (800 nm, 100 fs) at different intensity is investigated by a two-dimensional hydrodynamic model. The ablation rates are compared between the cases in vacuum and in air over a wide range of laser power density. It has been reported before that at low ($<10^{13}$W/cm^2) and moderate laser intensity ($10^{13} – 10^{14}$W/cm^2), two different ablation regimes exist, and the ablation depth per pulse is dependent on the optical penetration depth and electron heat penetration depth, respectively. By considering both collisional and collisionless absorptions, the model in this study predicts the third ablation regime with a much higher ablation rate increase with respect to laser intensity in the high intensity range ($>10^{14}$W/cm^2) in vacuum, which shows good agreement with the experimental data. This phenomenon is attributed to the change of dominant absorption mechanism from collisional to collisionless absorption. For the case in air, the ablation depth