Effects of shielding and re-deposition mechanisms during GHz double-pulse irradiation of a thin gold film

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The topographies of ablation structures upon irradiation with ultrafast laser bursts in the MHz–GHz regime differ significantly from those of conventional pulsing [1]. However, the underlying physical mechanisms remain poorly understood. To address this, a thin gold film ($d_z = 100$ nm, 20 nm adhesion layer of chromium, glass substrate) is irradiated with single- and double-pulsed ultrafast laser radiation ($\lambda = 800$ nm, $\tau_\mathrm{H} = 40$ fs, $\Delta t = 400$ ps) with the fluences of 1.5 and 3.0 times the ablation threshold per pulse. The interaction of the laser radiation with matter, with particular emphasis on the second pulse, is complementary investigated by two-temperature hydrodynamics modeling (TTM-HD) [2] and high-resolution time-resolved imaging interferometry [3, 4]. Thus, after the first pulse induces spallation, the second pulse re-deposits the ablation plume, transferring impulse and energy to the non-ablated material. In contrast, shielding of the second pulse becomes more pronounced if the first pulse induces phase explosion. In addition, the formation of ring-like surface features within the ablation structures of the double-pulse (Figure 1) is explained by the measured and reconstructed dynamics of the ablation plume.

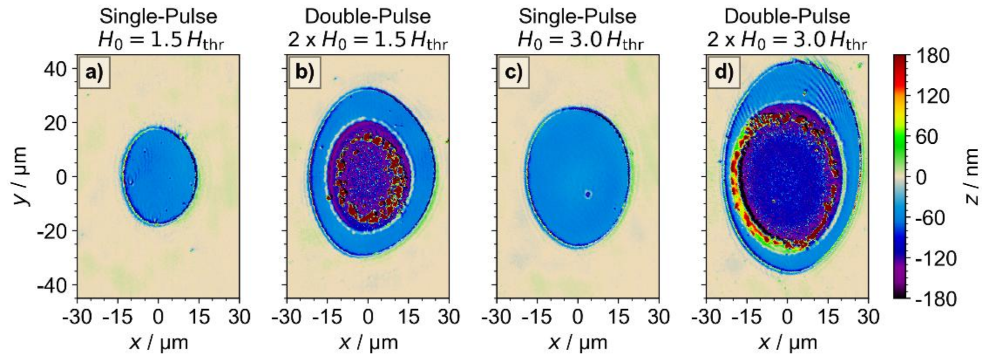

Figure 1: Topography of the ablation structures of a thin gold film upon irradiation with single- (a, c) and double-pulsed (b, d) ultrafast laser radiation for the fluences of 1.5 (a, b) and 3.0 (c, d) times the ablation threshold per pulse, measured with laser scanning microscopy.

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