Reconstruction of the ablation of thin gold films induced by ultrafast laser radiation

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Irradiating a thin gold film (film thickness approx. d_z = 100 nm, including an adhesion layer of 20 nm chromium) on a glass substrate with single-pulsed ultrafast laser radiation (pulse duration τ_{H} = 40 fs, wavelength λ = 800 nm) results in a step-like topography of the ablation structure, including the so-called gentle- and strong ablation substructure (Fig. 1a). Simulating the laser-matter interaction by two-temperature modeling in conjunction with hydrodynamics (TTM-HD) [1] (Fig. 1c) combined with ultrafast pump-probe metrology over 10 decades of time scales (fs- up to µs-range) (Fig. 1b) provides fundamental insights into ablation and increases the understanding of the process of ablating thin metal films [2,3]. Thereby, ultrafast pump-probe imaging ellipsometry [4] enables to measure the amount of absorbed energy, whereas a comprehensive combination of ultrafast pump-probe imaging reflectometry [2-5] and interferometry and modeling allows reconstructing the transient topography of all ablated substructures. This complementary approach reveals that a closed layer of liquid material formed by spallation remains undamaged until approximately 30 ns. In the case of phase explosion, the omnidirectional expanding gas-liquid mixture deforms this closed layer of liquid material. After 100 ns the closed spallation layer ruptures.

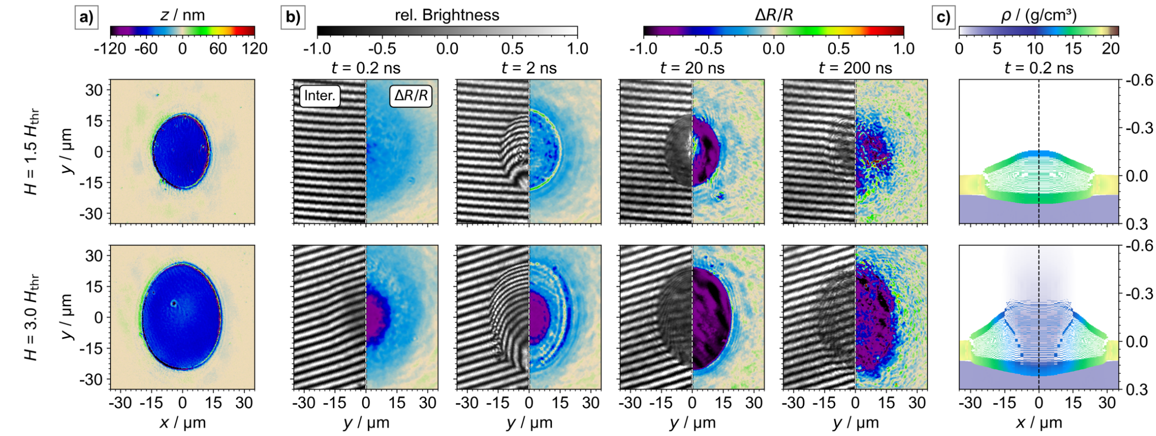

Figure 1: a) Experimentally determined topography of the ablation structure, b) measured transient interferogram and relative change of reflectance $\Delta R/R$ for the probe radiation (λ = 532 nm) after the excitation by the pump radiation (τ_{H} = 40 fs, λ = 800 nm) and c) calculated quasi two-dimensional distribution of the density ρ by TTM-HD

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References: [1] M. Olbrich, et al., OptLaserEng **129**, 106067 (2020); [2] T. Pflug, et al., JPhysChemC **125**, 17363 (2021), [3] T. Pflug, et al., OptLasTec **172**, 110540 (2024), [4] T. Pflug, et al., PhysRevB **106**, 14307 (2022), [5] T. Pflug, et al., AdvFunctMater 2311951 (2023)