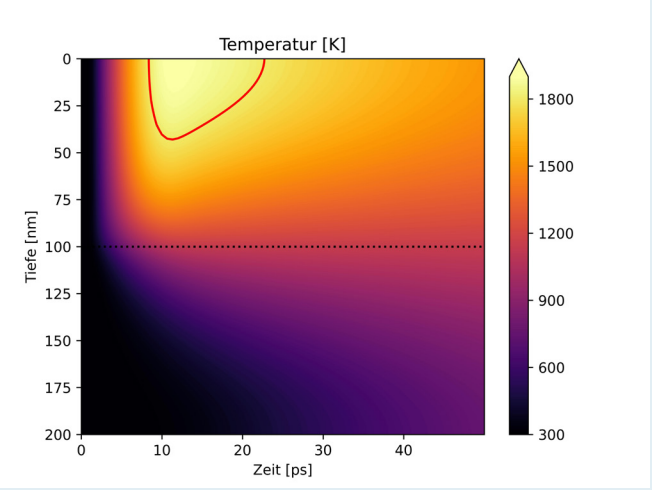

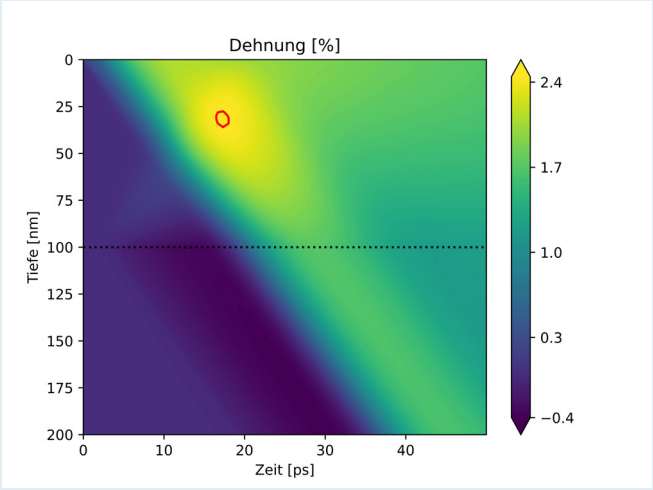

1 Simulated temperature distribution in a transparent thin film.
2 Simulated expansion distribution in a transparent thin film

Simulation-based analysis of the ablation of thin transparent layers

As the resolution of displays constantly increases and size of integrated circuits decreases, industry needs precise laser material processing of thin, transparent and semiconducting layers for displays and semiconductors. Depending on the application, the layers consist, for example, of low-κ materials, indium tin oxide (ITO), silicon dioxide (SiO_2) or silicon nitride (Si_3N_4) with layer thicknesses ranging from a few tens of nanometers to a few micrometers. Modeling the ablation process helps engineers design low-damage laser processes (e.g. to separate wafers or for OLED displays) faster and identify the physical effects on which the ablation process is based.

Model for simulating the ablation dynamics

In order to identify the underlying physical processes, engineers at Fraunhofer ILT and RWTH have developed a model that depicts the optical, thermal and mechanical properties of the thin films during and after irradiation with ultrashort laser pulses. The free electron density within the material changes drastically due to ionization as it is irradiated with intense ultrashort laser pulses. As a result, the optical properties of the material change during the laser pulse. By determining the induced energy, the institutes were able to model the resulting heating and thermal expansion within the thin films. Since the optical properties change during the laser pulse, the amount of energy introduced into the material could be determined and the resulting heating and thermal expansion in the material modeled.

Identification of the ablation mechanisms

This model can be used to predict the temperature and mechanical stress distributions in the material. If the mechanical stresses exceed a threshold value specific to a material, the ablation process is mechanically dominated. Similarly, an ablation criterion can be defined for thermally dominated ablation when the melting or evaporation temperature is reached. The ablation criteria are fulfilled for the areas marked in red in the illustrations above.

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