TOWARDS DESCRIPTION OF MECHANICAL DAMAGE OF THIN MOLYBDENUM FILM UPON PULSED LASER IRRADIATION

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Upon femtosecond laser pulse irradiation the experimental damage threshold of Mo thin films [1] can be well described by associating the damage with melting of the material [2,3]. For film thicknesses from ~20 nm up to bulk, a 1D description based on the two-temperature model (TTM) along with constant optical properties was sufficient to reach agreement with available experimental results in the ultraviolet regime.

For infrared irradiation, a Mo film exhibits strong changes of absorptivity as function of time and laser wavelength [4]. While electronic response of the solid may lead to a decrease of the reflectivity at high fluence, its optical response should also be affected by the expansion/compression of the lattice, as was shown for other metals [5]. A comprehensive description of the optical, thermal and mechanical effects is thus desirable for Mo.

In this work, as a first step, we study the role of stress as a damage mechanism for a thin molybdenum film deposited on a glass substrate and irradiated by an ultrashort laser pulse using two different models: an hydrodynamic model and a thermo-elastic model. Coupled with a two-temperature model (TTM) and an equation of state, the hydrodynamical description enables us to compute the pressure and density of the solid as function of laser irradiation parameters. A Lagrangian approach [6] was adopted to easily determine the laser-induced motion of the free surface. The thermoelastic model, relatively simpler to implement, is based on the two temperature energy balance equations supplemented by an equation tracking the lattice displacement induced by the thermal stress [7] but without accounting for the deformation of the material.

This work provides insights on the damage mechanisms of laser-irradiated thin metallic films, a step of importance for improving the control of thin film modification by pulsed laser light.

References

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