Numerical Simulation of Ultrashort Pulse Laser -Material Interaction with an Angle of Incidence

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The ultrashort pulse laser has widely been used for the micro-drilling of metals in many industrial applications such as aerospace, biomedical, and semiconductors. Precise shape and size of the micro holes were mostly required for cooling of the gas turbine blades in the aerospace industry [1]. To improve the cooling effectiveness, different shaped micro holes have been drilled with an acute angle ranging from 15 to 35 degrees on the turbine blade [2]. When the ultrashort pulse laser beam incident on the target surface with an angle, the optical properties of the material changes with angle of incidence. Further, the polarization effect plays a significant role in the laser intensity distribution on the target surface [3-4]. Therefore, detailed investigations of the ultrashort pulse laser material interaction with the angle of incidence are highly required.

In the present work, the ultrashort pulse laser material interaction on an inclined surface is investigated based on a 2D two-temperature model (ttm) with an angle of incidence. The numerical simulations are carried out by using the finite element-based COMSOL Multiphysics software. The influence of optical properties with the angle of incidence on the inclined surface is explored by considering the polarization effect. The electron and lattice temperature distribution are predicted from the simulation results for different laser fluences. Further, the ultrashort pulse laser ablated crater profiles are predicted using the moving mesh approach for different angles of incidence. The present simulation approach is useful for the selection of laser process parameters in the ultrashort laser-material interaction with an angle of incidence.

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