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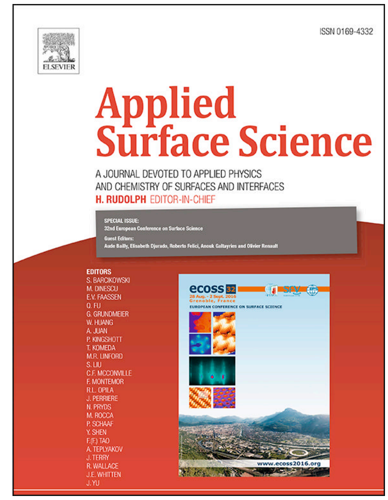

Full Length Article

Numerical study of material decomposition in ultrafast laser interaction with metals

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Numerical study of material decomposition in ultrafast laser interaction with metals

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Abstract

A study of ultrafast laser-induced ablation of metals is presented based on an improved two-temperature model. Material decomposition and the resultant energy loss from the sample are considered through the dynamic description of the ablation process. The boiling temperature is adopted as the ablation initiation temperature to capture the contributions from multiple ablation mechanisms. Ablation occurrence period, ablation depth, threshold fluence, residual thermal energy and melting layer thickness have been studied for aluminum, copper, and gold. The simulation results agree well with the experimental measurements for different materials and laser parameters. The electron-phonon coupling strength and thermal conductivity are found to be critical factors determining ablation behaviors. With strong electron-phonon coupling and low thermal conductivity (like aluminum), ultrafast ablation can be triggered within hundreds of femtoseconds, leading to a more efficient laser energy deposition, high ablation depth, and thin melting layer.

Keywords: Ultrafast laser, laser-matter interaction, ablation, two-temperature model, heat-affected zone

1 Introduction

Ultrafast (pulse duration shorter than 10 ps) laser-induced ablation (ULIA) of metals, with low ablation threshold, high processing efficiency, and small heat-affected zone (HAZ), has been a subject of interest for decades due to its great potential for high-precision micromachining. Extensive experimental and numerical investigations [1-6] have been devoted to the study of