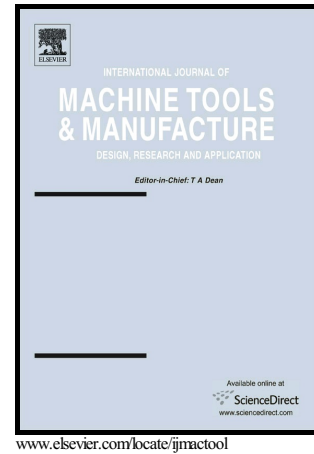


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Heat transfer and material ablation in hybrid laser-waterjet microgrooving of single crystalline germanium

Hao Zhu¹, Jun Wang^{1*}, Peng Yao^{2*}, Chuanzhen Huang²

¹School of Mechanical and Manufacturing Engineering, UNSW Australia, Sydney, NSW 2052, Australia

²Centre for Advanced Jet Engineering Technologies, School of Mechanical Engineering, Shandong University, Jinan, China

jun.wang@unsw.edu.au
yaopeng@sdu.edu.cn

*Corresponding authors. Tel: +61-2-9385 5784

Abstract

A numerical model describing the heat transfer and material ablation in a hybrid laser-waterjet microgrooving process for a single crystalline germanium (Ge) is developed, considering the relevant physical phenomena involved, such as laser-induced plasma (or optical breakdown) in water, laser beam attenuation in the plasma zone, heat transfer in Ge substrates, and waterjet cooling and impinging effects. The model is then verified, which shows that the respective calculated and measured quantities are in reasonably good agreement. A numerical simulation study is then carried out using the developed model and demonstrates that the shielding effect of the laser-induced plasma increases with the laser pulse energy. In addition, the irradiated material can be expelled by a waterjet at its soft-solid status, and heat accumulation in the workpiece is effectively removed by the waterjet cooling effect during the off-pulse period, so that laser heating induced thermal damage is minimized. The effect of processing parameters on the ablation process is also analysed. It has been noticed that an increase in laser pulse energy leads to a deeper groove, and an increase in the applied water pressure decreases the threshold workpiece temperature for material removal.

Keywords: Laser ablation; Micromachining; Hybrid laser-waterjet; Germanium; Heat transfer; Plasma.

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