SUMMARY OF Ph.D. DISSERTATION

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Title

Ablation processing of functional materials by femtosecond laser pulse

Abstract: The intense ultrashort pulsed laser interaction with functional materials is a subject of practical interest as well as material science interest. Significant advancements in broadband solid state lasers and the chirped pulse amplification technique using Ti:sapphire, Cr:LiSAF and Cr:LiCAF laser media have led to the challenging phase of this research. The application fields include high-intensity physics, ultrashort pulsed laser ablation, high order harmonics generation, and so on. The femtosecond laser ablation is one of the most promising technologies among the femtosecond laser applications because ablation physics is drastically different from those of conventional nanosecond and longer pulsed laser ablation. As for metal ablation, theoretical investigations on the short pulse laser ablation of metals have been reported. The femtosecond laser ablation is numerically simulated using a two-temperature model, and the heat conduction equation. The molecular dynamics (MD) simulation is mainly used without any assumptions to describe the physical phenomena of the interaction of ultrashort laser pulses with different materials and rarely to evaluate the ablation depth and laser melting. The main objective of this dissertation is to study the ablation characteristics of functional materials by femtosecond laser pulse.

Chapter 1 presents the motivation, background and previous studies as the introduction of this dissertation. Chapter 2 describes femtosecond laser ablation theoretically. The ablation of metals by femtosecond laser is theoretically described using a two-temperature model. In Chapter 3, theoretical calculation of femtosecond laser ablation is performed using a two-temperature model and a molecular dynamics simulation. Femtosecond laser ablation is expressed by molecular dynamics simulation that takes account of the electron contribution calculated by a two-temperature model. The ablation rate and the thickness of heat-affected zone are estimated theoretically. Chapter 4 shows the ablation of metals by femtosecond laser. The ablation rate and the heat effects of metals are evaluated. Chapter 5 presents the thickness of heat-affected zone of metals ablated with femtosecond laser pulse experimentally. The dependence of the thickness of heat-affected zone on the laser fluence is analyzed. Additionally, the theoretical results are compared with the experimental one. Chapter 6 describes the ablation characteristics of AlN and BN ceramics by femtosecond laser pulse. The ablation rate, the chemical composition, and the surface shape are measured. In addition, the ablation characteristics by nanosecond and picosecond laser pulse are also shown, and the difference of the ablation characteristics caused by the pulsewidth is analyzed. Chapter 7 describes the conclusion.