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SPACE PROPULSION SYMPOSIUM (C4)
Advanced Propulsion: "Non Electric Non Chemical" (8)

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NANOSECOND PULSED LASER ABLATION OF POLYTETRAFLUOROETHYLENE BASED PROPELLANTS: NUMERICAL ANALYSIS OF THERMAL AND MECHANICAL EVENTS

Abstract

Polytetrafluoroethylene(PTFE, or Teflon) based propellants may be used in laser propulsion and other advanced propulsion systems. Thermal and mechanical events, including plasma forming and expanding, druing nanosecond pulsed laser ablation of PTFE based propellants were investigated. As assumption pure PTFE of different density and Al/PTFE control samples were set up into a coaxial combustion chamber and subjected to a nanosecond pulsed laser. Resultant of laser ablation jetted spread into the vacuum circumstance penetrating through a nozzle. A non-Fourier heat transfer model in the ablation process of PTFE or Al/PTFE compositions by nanosecond pulsed laser was established first, and taking phase transition and radiation into account, the three dimensional temperature distribution in the compositions was calculated. Considering thermo-chemical non-equilibrium effect and using the CFD method, distribution of density, temperature, number density, pressure, and other parameters in the chamber was also calculated for the plasmas of PTFE or Al/PTFE. In addition to providing properties of resultant of PTFE based propellants, the above numerical simulation also provided insight into physical mechanisms of laser ablation and thrust forming in the laser propulsion. The impulse and thrust induced by pulsed laser ablation was also calculated to evaluate the energy utilization efficiency of the thruster. It was shown that the processes of laser ablation and energy transport in the chamber were influenced intensively while changing the contributing factors, such as laser power density, pulse width, wave length, single pulse energy, laser output repetitive rate and the material physicochemical property of PTFE and Al/PTFE. Based on the numerical analysis and calculation, optimal parameters of laser beam and propellants composition were configured to increase the energy utilization efficiency in the process of laser ablation and thrust forming.