Study of Energy Conversion Process in CW laser Propulsion

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Abstract

Laser propulsion has been investigated as one of the propulsion systems that may be used in space and in the atmosphere. A laser-sustained plasma (LSP) which absorbs the high power laser beam from a remote site is produced in the thruster. The propellant gas is heated by the LSP and gas enthalpy is converted into thrust kinetic energy through a supersonic nozzle. Therefore, total energy conversion efficiency is given by efficiencies of each process. LSP was sustained at the position where absorbed laser energy balances lost energy. In this way, thruster performance depends on energy balance in energy conversion processes. To improve the performance, it is necessary to clarify each conversion processes.

In our previous works, the thrust performance remarkably increased when a sub-chamber was added to main chamber of the thruster. However, the reason for this improvement has not yet been discussed. This paper discusses the reason from the viewpoint of the condition of LSP sustaining and the laser absorption efficiency.

Measuring the relation between flow velocity and LSP position from the focus, we obtained LSP movement condition. Once LSP goes into the sub-chamber, it cannot move upstream beyond the sub-chamber entrance to upstream because of the movement condition, and LSP was trapped into the region of higher energy density. Measured absorption efficiency was almost proportional to laser power density. Therefore, increasing the laser power density by sustaining LSP at the position as possible as near the focus is important to increase the absorption efficiency in this condition and using the sub-chamber would effectively satisfy this requirement.

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