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Study on Electron Beam Deposition Energy Measurement Method for Flyer Impact with Intense Pulse Power Generator
大強度パルスパワー装置を用いた飛翔体加速のための電子ビーム付与エネルギー計測法の検討

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Diamond-Like Carbon (DLC) is expected to be a material of guiding-cone for fast ignition. The guiding-cone at the irradiation of heating laser becomes warm dense matter, in which physical properties are unclear. In this study, to generate warm dense DLC, we proposed a flyer impact method using intense electron beam generated with an intense pulsed-power generator. Electron beam energy was estimated from electron beam current and voltage of the pulse-transmission line. To evaluate provided energy fluence for flyer, we considered the measurement method of energy fluence of electron beam by using calorimetry.

1. Introduction

Nuclear fusion energy is expected as a solution of energy problems [1]. Inertial confinement fusion irradiates intense lasers a fuel target. The fuel becomes high temperature and pressure by reaction force from expanding plasma on target surface.

To increase the energy conversion efficiency from a laser to core plasma for fast ignition of inertial confinement fusion, a guiding-cone is used for the fuel target. Diamond-Like Carbon (DLC) is expected to be a material for the guiding-cone because low-Z material decreases a divergence angle of fast electron and radiation loss [2-3]. The guiding-cone becomes warm dense matter at the irradiation of the additional heating laser. However, physical properties of warm dense DLC affect the conversion efficiency in the ignition laser.

To generate warm dense DLC, we proposed a flyer impact method generated by the intense electron beams. A flyer is accelerated by reaction force from the ablation plasma generated by the irradiation of electron beam. The electron beam is provided by using the intense pulsed power generator "ETIGO-II" [4]. Warm dense DLC is generated by the flyer impact in which has advantages such as well-defined plasma parameters and determination of state of matter using Rankine-Hugoniot relation. In this study, to generate warm dense DLC, we have estimated the electron beam energy and considered the measurement method of energy fluence of electron beam.

2. Experimental setup and result

Figure 1 shows a configuration of electron beam diode of ETIGO-II for measuring electron beam energy. The diode consists of a disk cathode and a mesh anode. The material of electrodes was stainless steel. A gap distance between the anode and the cathode in electron beam diode is 13 mm. The electron beam passes through the mesh anode. The cathode current and the electron beam current were measured with Rogowski coils. Output voltage was measured with a capacitive voltage divider in the pulse-transmission line (PTL) of ETIGO-II. Figure 2 shows typical output of ETIGO-II. Electron beam energy was estimated from

$$E = \int I_{e-beam}(t) V_{PTL}(t) dt \qquad (1)$$

where, I_{e-beam} and V_{PTL} are the electron beam current and the PTL voltage, respectively.

Figure 3 shows estimated electron beam energy as a function of PTL voltage. The estimated electron beam energy is 700-900 J. Since the electron beam energy is estimated from the electron beam current and the PTL voltage, all of the energy is not converted to the kinetic energy of the flyer. To estimate the flyer energy, we should measure the energy fluence in the target. Configuration for measuring the energy fluence of electron beam is shown in Fig. 4. The electron beam is focused by curved shape electrode at 135 mm. A calorimeter is set at the back of aperture. Temperature of the calorimeter rises by the electron beam irradiation. Temperature of the calorimeter is measured using a

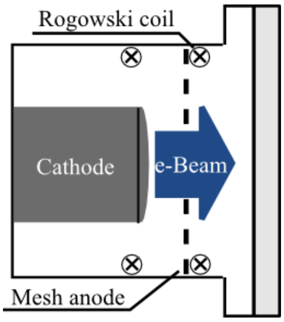

Fig.1 Configuration of electron beam diode for measuring electron beam energy.

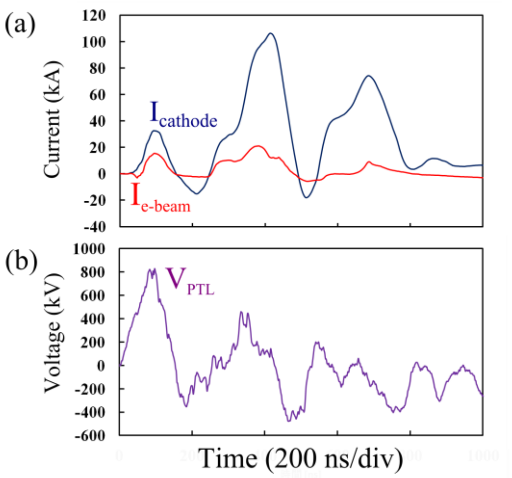

Fig.2 Typical output of ETIGO-II for (a) cathode current and electron beam current and (b) voltage of pulse-transmission line.

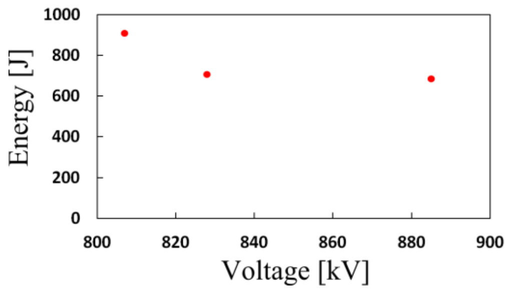

Fig.3 Estimated electron beam energy as a function of PTL voltage.

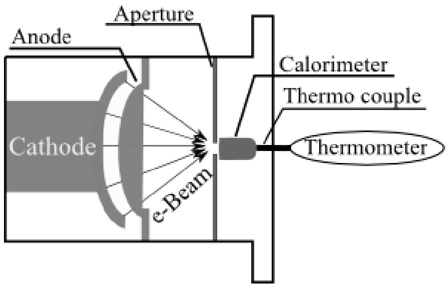

Fig. 4 Configuration for measuring the energy fluence of electron beam.

thermometer connected to the thermo couple. The energy fluence of electron beam is estimated using incremental temperature from

$$\Psi = \frac{C_V m \Delta T}{S}, \qquad (2)$$

where, Ψ, C_V, m, ΔT, and S are the energy fluence, the specific heat capacity of the calorimeter, the mass of the calorimeter, the incremental temperature of the calorimeter, and the area of aperture, respectively. The energy fluence of the electron beam will be estimated with the calorimetry.

3. Summary

To generate warm dense DLC by using the flyer impact method with the intense pulsed power generator ETIGO-II, the electron beam energy was measured. Electron beam energy is estimated to be 700-900 J. The measurement method of energy fluence of electron beam using the calorimetry was considered.

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