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Characteristics of fast electrons generated by interaction between high intense picosecond laser and preplasma-filled cone-guided target

高強度ピコ秒レーザーと長尺プリプラズマ付きコーンターゲットとの相互作用により発生する高速電子の特性

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Large-scale simulations of interaction between high-intensity picosecond laser and cone-guided target with and without preplasma have been performed. Features of the supposed laser, which are high power, long pulse (1 kJ / 1–5 ps), and large spot diameter (30–60 μm), cause the interesting results that differ from many usual short pulse laser experiments. Results show that preplasma enhances laser absorption, but decreases beam intensity of forwarding electrons and low-energy electrons that heats the core efficiently.

1. Introduction

Fast Ignition Realization Experiment project phase-I (FIREX-I) [1] has been furthered in Institute of Laser Engineering, Osaka University. In this project, cone-guided target is used to guide the heating laser close to the core. The goal of this project is to achieve the ignition temperature of 5 keV by fast heating of ultrahigh intense laser, LFEX.

Features of the LFEX, which are high power, long pulse (1 kJ / 1–5 ps), and large spot diameter (30–60 μm), are considered to cause interesting results that differ from many usual researches, where the laser is ultrahigh intensity, but femtosecond and small spot size close to the diffraction limit. Kemp et al. [2] reported that a high power long pulse laser such as the LFEX creates a large underdense plasma during first 1 picosecond, after that the laser interacts with the self-generated large underdense plasma, and the effective temperature becomes high even in the case of initially no pre-plasma.

Simulation of Kemp et al. was the case of a planar target. So, we perform large-scale simulations in the case of the cone-guided target. Similar tendency is predicted, but the cone affects plasma expansion, hence fast electron generation and its characteristics. Furthermore, LFEX has prepulse, thus the inside of the cone may be mostly filled by preplasma before irradiation of main pulse. Preplasma effects are also simulated.

2. Simulation Conditions

Interactions between high-intense picosecond laser beam and the preplasma-filled cone-guided target are simulated with 2-D Particle-In-Cell code. Figure 1 shows two-dimensional electron density profile of the preplasma-filled target at the beginning. The Au cone is introduced as 10 μm thickness, $100n_{cr}$, real mass, and Z = 40 plasma, where n_{cr} is the critical density. The outside of the cone is surrounded by CD plasma

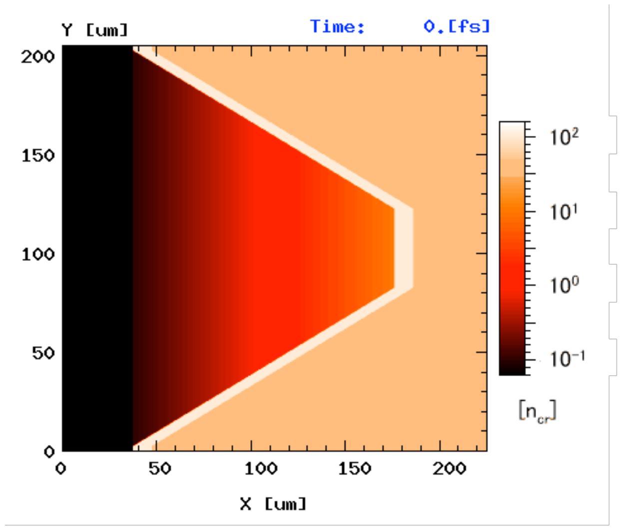

Fig. 1. Initial electron density profile of the target

with the density of $40n_{cr}$, Z_C = 12, and Z_D = 1. The inside of the cone is filled by preplasma, which has exponential profile of the scale length of 30 μm with the density from 0.1 to $10n_{cr}$. From the left boundary, temporally flattop and spatially Gaussian laser beam irradiates the cone tip at normal incidence. The pulse duration is semi-infinite, the peak of averaged intensity is 10^{19} W/cm^2, and the spot diameter is 60 μm at full width of half maximum. The laser beam is linearly polarized and the oscillating electric field is parallel to y direction.

3. Results and Discussions

Figure 2 shows time-evolution of reflectivity that is calculated by observing incident and reflected laser lights at x = 0 μm. In the case of no preplasma, the laser light interacts with overdense plasma directly and reflects efficiently. In contrast, the large underdense preplasma absorbs the laser light mostly when the preplasma is filled inside the cone. It is obvious that the

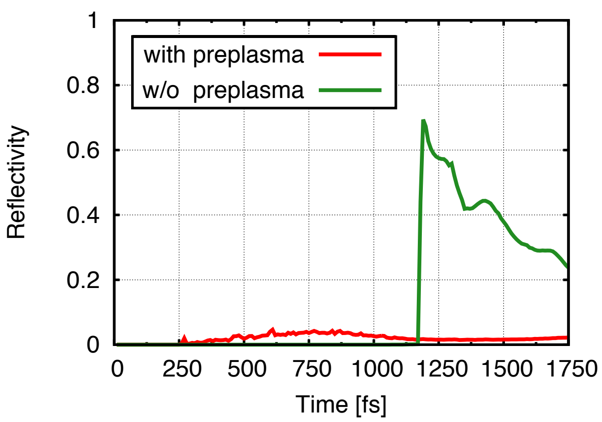

Fig. 2. Time-evolution of reflectivity

preplasma enhances laser absorption. However, the beam intensity of forwarding electrons in the case of the target with preplasma is lower than that of the no preplasma case as shown in Fig. 3, where the forwarding electrons observed at x = 186 μm, namely rear surface of the cone. It means

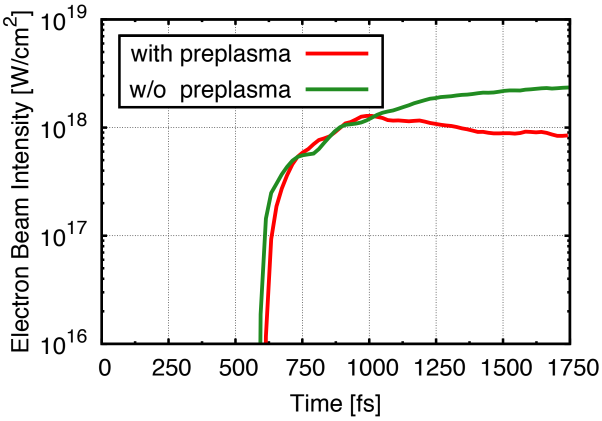

Fig. 3. Time-evolution of electron beam intensity

that generated fast electrons is so diverged that most of them is not observed despite of the high absorption in the preplasma-filled target case.

Finally, time-integrated energy spectra of electrons that are observed at x = 186 μm are shown in Fig. 4. Low-energy electrons in the case of no preplasma are more generated than that in the case of the preplasma-filled target. From the standpoint of the fast ignition, electron characteristics in the case of no preplasma are suitable because few MeV electrons heats the core efficiently. Thus, the preplasma reduction will promise the improvement of the core heating.

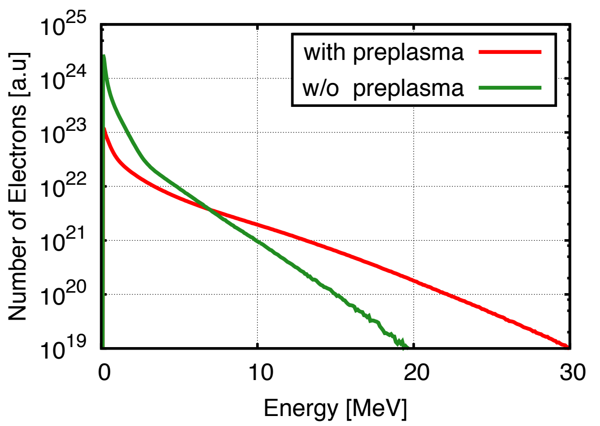

Fig. 4. Time-integrated electron energy spectra

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