§38. Design Study on Foam-cryogenic Targets by Integrated Simulations

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The purpose of this study is to analyze the recent fast ignition experiments with cone-guided targets and carry forwards a design of form-cryogenic targets, on the basis of the integrated code system, FI^3. In FY2007, the following simulations were conducted.

1. Implosion properties of cone-guided shell target

Implosion simulations were performed using 2-D radiation-hydro code PINOCO for a cone-guided CH shell target model. It was assumed that the target is irradiated by uniform laser whose wavelength, energy and pulse width are 0.53µm, 4.5kJ and 1.5ns (Gaussin, FWHM), respectively.

Table 1 summarizes the result of simulations. It is found that with increasing target mass, the implosion velocity decreases and high areal density ρR is attained.

Table 1 Summary of implosion simulation

	outer radius	thickness	fuel mass
Case 1	250 µm	8 µm	6.08 µg
Case 2	250 µm	10 µm	7.54 µg
Case 3	300 µm	10 µm	10.93 µg

	$v_{imp,\,max}$ (cm/s)	ρR_{max} (g/cm^2)
Case 1	3.60×10^7	0.50
Case 2	3.16×10^7	0.51
Case 3	2.80×10^7	0.60

2. Analysis of core heating by long-pulse laser

1-D simulations (PIC + Fokker-Planck) were performed to investigate the core plasma heating by long-pulse (10ps) laser. In the PIC simulations for laser-cone interactions, the cone tip is modeled by $n_e = 500\, n_{cr}$ 10µm thickness plasma (Au ion with Z = 30 and real mass), and it is irradiated by the heating laser with the intensity of 10^{20}W/cm^2. The pre-plasma having a density profile $n_e \sim \exp(x/L_f)$ with scale length L_f = 1, 5, 10µm was attached to the front surface. When the heating laser with long pulse is applied, the low-density pre-plasma, created on the laser-irradiated surface, is pushed by the pondermotive force of the laser, resulting in a steep density profile. The laser thus interacts directly with the high-density plasma, and the intensity of laser-produced electron beam is decreased. As is shown in Fig.1, the intensity I_e of beam electrons, formed after density profile steepening, becomes proportional to $n_e^{-1/2}$, where n_e is the electron density in the interaction region.

Using the beam electron profile evaluated by PIC simulation, we made Fokker-Planck simulations of the core plasma heating, where the CD imploded core profile obtained in the 2D implosion simulations was used. Figure 2 shows the temporal evolution of the average core electron temperature. When the scale length L_f is relatively short, the core plasma temperature does not rise so much. This is because the beam electron intensity decreases rapidly due to fast steepening of the density profile. With increasing scale length, reduction of the beam electron intensity due to the steepening is retarded; the core heating efficiency is improved, resulting in the core temperature above 2 keV.

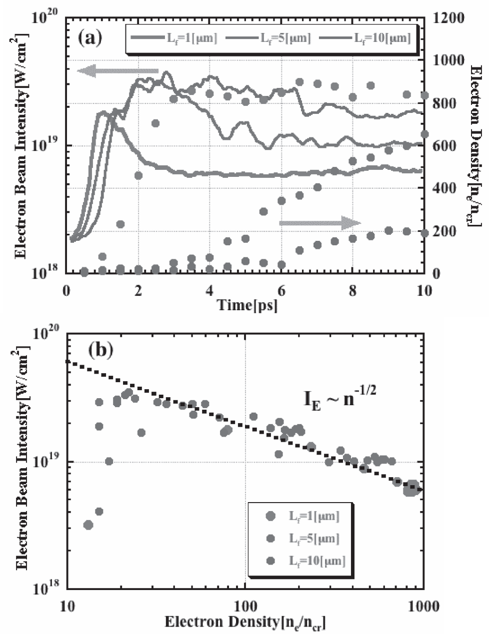

Fig. 1 Beam electron intensity and electron density

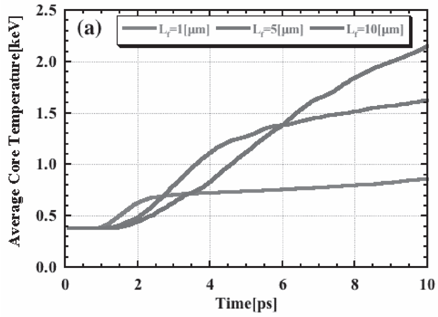

Fig. 2 Evolution of average core electron temperature

It is thus concluded that when the core plasma is heated by long-pulse laser, suppression of the rapid steepening of the density profile is required to keep high the beam electron intensity. For this purpose, we propose coating of the inner surface of the cone tip with low-density materials such as aerosol.

Major publications

1) T. Johzaki, et al., *Laser Part. Beams*, **25**, 621-629, 2007.
2) T. Johzaki, K. Mima, Y. Nakao, *Plasma Fusion Res.*, **2**, 041 1-8, 2007.
3) H. Sakagami, K. Mima, *ibid.*, 026 1-4, 2007.
4) T. Nakamura, et al., *Phys. Plasmas*, **14**, 103105 1-7, 2007.
5) H. Nagatomo, et al., *ibid.*, **14**, 056303 1-7, 2007.
6) T. Nakamura, et al., *Plasma Fusion Res.*, **2**, 018, 2007.
7) T. Johzaki, Y. Nakao, K. Mima, *Phys. Plasms*, **15**, 062702 1-7, 2008.