§54. Formation of High Areal Density Core Plasma using Slow Velocity Implosion

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In fast ignition scheme, the high energy electron or ions is applied to achieve the ignition condition of the temperature, where a central hot spot (CHS) is not required [1]. That is, the implosion core required for fast ignition system is different from that of the CHS scheme. Only the main fuel of the low temperature and high density is required in fast ignition. Therefore, it is necessary to design targets, which is different from that of the CHS[2].

One of the realistic solution is "slow velocity implosion" scheme, where a hot spot is not formed. Another advantage of the scheme is the suppression of the Rayleigh-Taylor instability. In order to avoid the mass density reduction due to hydrodynamic instability, the acceleration of the imploding shell should be kept low. In addition, reducing the velocity of the inner shell is important to prevent stagnation, and the keeping the shell in low isentrope is ideal. Due to the delay of the installing the arbitrary laser pulse shaping system, we have been studied the advanced target design for fast ignition.

Recently, we obtained a new target design, where solid ball target is applied instead of shell target. The advantage of the solid target is reduction of hydrodynamic instability because shell is not accelerated during the implosion. And the hot spot is not existed at the center. In addition, we can achieve higher compression if we can use tailored pulse laser[3].

Implosion simulation of solid ball target

An implosion simulation of a solid target is executed to validate the compression method. A solid CD target (radius=100 μm) with a gold cone (45 degree of open angle, and thickness is 15 μm) is assumed (Fig.1) ρR=60mg/cm^2 Simulation conditions are based on the specification of the current direct drive implosion laser GXII[3], except the tailored pulse shaping. The total energy and the wavelength of the laser are assumed as 300 J/beam and 0.53 μm respectively. The tailored laser pulse is applied and its duration is limited to 5 ns due to the GXII limitation. The maximum intensity is limited to 10^{16} W/cm^2. The LPI models are not taken account into the simulation.

Figure 2 shows the time evolution of areal density and laser power. The maximum areal density is reached 0.13 g/cm^2, which is 2/3 of the spherical target without gold cone case. When we apply the Gaussian shape pulse instead of the tailored pulse, the areal density is 0.06 g/cm^2.

In the FIREX-I project, imposing the external magnetic field is planned to guide heating electron beam. In our previous study, magnetic field cause hydrodynamic instability due to the anisotropy of the electron thermal conduction [4]. If we use the solid target this side effect is reduced. However, the life time of the magnetic field is a few ns. Applications of the tailored pulse together with external magnetic field must be considered carefully.

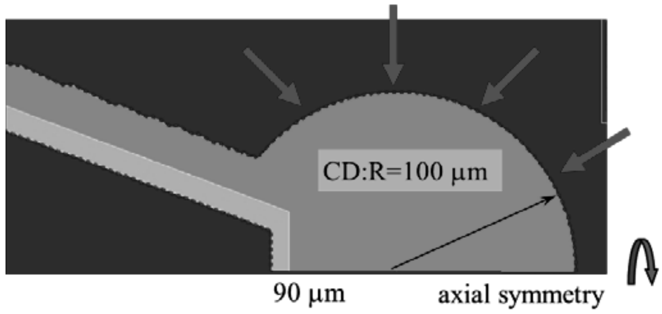

Fig. 1. Configuration of the solid target for FIREX-I experiment. gold cone is attached to a CD ball target. The radius of the CD target is 100 μm. The thickness of the tip of the cone and open angle are 15 μm and 45 degree respectively.

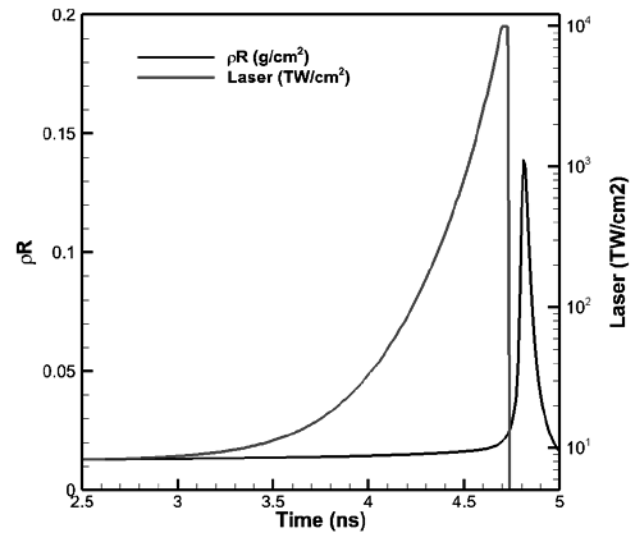

Fig. 2. Areal density (black line) and laser power (red line).

Summary

Slow implosion has advantage to create a high areal density core plasma for fast ignition. Furthermore, solid target is more effective than shell target. Especially, if we impose the external magnetic field, hydrodynamic instability caused by anisotropy of electron thermal conduction can be avoided. A tailored pulse improves the compression efficiency, which is great advantage for the fast ignition scheme.

1) R. Betti and C. Zhou, *Phys. Plasmas* **12**, (2005) 110702.
2) M.H. Key, *Phys. Plasmas* **14**, (2007) 055502.
3) R.E. Kidder, *Nuclear Fusion* **14**, (1974).
4) H. Nagatomo *Nuclear Fusion* **55** (2015) 093028.