§12. Development of Fast Ignition Target

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A cryogenic target for FIREX-1 has been developed under bilateral collaboration between Institute of Laser Engineering (ILE), Osaka University and National Institute for Fusion Science (NIFS). The fuel shell that consists of low density foam capsule coated with a gas barrier and a guide cone is developed at ILE, Osaka and fueling experiments are carried out at NIFS. Although the target fabrication technique is still underway, we improved target design to increase the coupling efficiency of heating laser to the absorbed energy in the compressed core. The initial design of the target is shown in Fig 1 (a) and the advanced design is illustrated in Fig. 1(b). Five important modifications are adapted as followed.

The coupling efficiency is expected to be increased by the following two ways:

1) Low-Z foam layer on the inner surface of the cone.

There is an optimum plasma density of the inner surface of the conical light guide for good coupling. If the density is too low, hot electron temperature becomes too high to be efficiently absorbed by the core plasma. If the density is too high, the temperature becomes too cold (due to the shallow skin depth) to penetrate deep into high-dense core. The optimum plasma density can be realized with a low-density foam layer on the inner surface of the cone. Our previous experiment has demonstrated the increased coupling by using a low-density gold foam [1]. Low-Z plastic foam is desired for efficient electron transport.

2) Double cone.

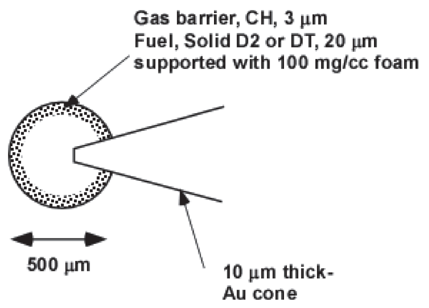
A conical light guide with additional outer wall is preferable. Electrons generated in the inner surface of the double cone will return by sheathe potential generated between two cones. Our two dimensional PIC simulation indeed indicates the improvement of the electron confinement by a factor of 1.7 [2].

The implosion performance is to be improved by three ways:

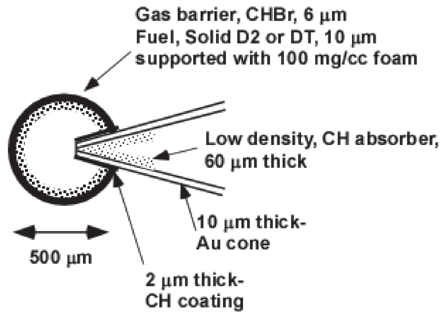
1) Low-Z plastic layer on the outer surface of the cone may suppress the expansion of Au cone that flows into the interior of the compressed core. The 2-D hydro-simulation PINOCO predicts that the target areal density increases by a factor of two if we employ this scheme. 2) Br doped plastic ablator may significantly mitigate the Rayleigh-Taylor instability [3], making implosion more stable.

3) Evacuation of the target center. If there is a substantial amount of the fuel gas in the target, it generates a gas jet that may potentially destroy the cone tip and thus hinder the efficient coupling of the heating laser with the plasma. This unwanted effect was indicated in the previous Japan-US collaboration experiments

Another important technology in fast ignition target is control of fuel mass and characterization of basic target properties that determine implosion timing. The density of foam, the thickness of the foam layer and the gas barrier must be characterized with an accuracy of +/- 1%.



(a)



(b)

Fig. 1 Conventional design of fast ignition target for FIREX 1 (a) and the advanced design (b).

A shearing interference microscope was used to observe the phase image of the beam through the target. Effective refractive indices of foam and the foam saturated by hydrogen are evaluated by the formula of Lorentz-Lorenz function. This system can measure the optical properties of the target with an accuracy of +/- 0.1 $.

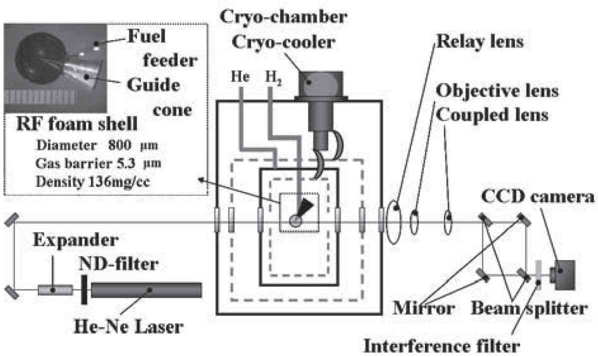


Fig. 2 Characterization system for cryogenic cone target

[1] A. L. Lei et al., Phys. Rev. Lett. **96**, 255006 (2006).
[2] T. Nakamura et al., Phys. Plasmas **14**, 103105 (2007).
[3] S. Fujioka *et al.,* Phys. Rev. Lett. **92**, 195001 (2004).