§31. Researches on Fast Ignition of Cryogenic Deuterium Targets

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Status of LFEX laser

In 2007, the installation of large gratings into the pulse compressor of LFEX (Laser for Fusion Experiment) started and the first test of the pointing control was successfully operated. Figure 1 shows the world-largest gratings in the vacuum vessel of the pulse compressor.

Fig. 1 Gratings for pulse compression of LFEX

Target development

Development of cryogenic foam targets are continued as the collaboration program between Osaka University and NIFS (National Institute for Fusion Science).[1] In 2007, we concentrated our effort on fabrication of new foam shell and development of characterization technique for fuel assay. The foam material was changed from resinol / formalin (RF) foam to phloroglucinol carboxylic acid / formaldehyde (PF) foam because the viscosity of RF foam solution is too low to fabricate 500-μm-diameter, 20-μm-thick foam shells.

Plasma experiment

Implosion experiments of fast ignition targets have been performed with the Gekko-XII laser.

Detailed implosion hydrodynamics of a shell target with a cone was investigated by using ultrafast x-ray spectroscopic imaging technique. A new Multi-channel Multi-Imaging X-Ray Streak Camera (McMIXS) was developed to observe time-resolved two-dimensional x-ray images in multi spectral channels enabling us to derive time-resolved two dimensional, temperature distributions with time- and special resolutions of 24 ps and 20 microns, respectively.

It was found that the shape of the core is neither spherical nor uniform and moving toward the tip of the cone and interacting with it. Experimental results are compared with two-dimensional hydrodynamic simulations. Target design taking into account of these phenomena is quite important because such core movement and jet formation can affect the condition of the cone.

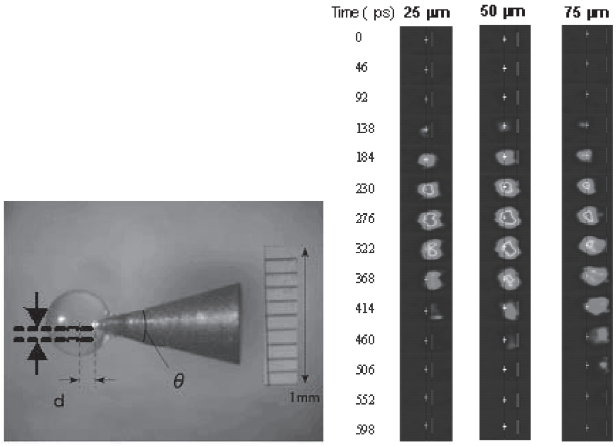

Fig. 2 Influence of cone on the imploded core.

Integrated simulation of fast ignition

About the generation of high energy electron for heating the core plasma, two-dimensional large scale Particle-in-Cell simulation on generation of high energy electron is executed to optimize the cone angle. In the result, the Sub-MeV electrons which are preferable for heating core plasma in fast ignition are mostly generated in 30-degree cone target, where surface acceleration takes place. We proposed a double cone that has a vacuum insulation layer in the cone wall. This geometry can improve the focusing of electrons for the core heating as shown in Fig. 3. [2] When there is corona plasma around the cone, hot electrons diffuse into the corona as shown Fig 3 right. The vacuum insulation layer keeps the potential of the inner cone and guides electrons toward the tip of the cone.

Also, in consideration of a formation of high density core plasma, and effective hot electron transport, an advanced target where inner and outer surface of the cone is coated by the plastic is proposed.

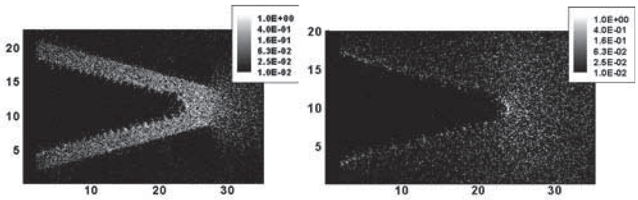

Fig. 3 Energy density of hot electrons in a double cone with vacuum insulation layer (left) and single cone (right).

[1] A. Iwamoto, et. al., Fusion Sci. Technol., 51 (4), 753-757, (2007).

[2] T. Nakamura, et al., Phys. Plasmas 14, 103105, (2007).