§10. Development of Fast Ignition Target

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A cryogenic target with a unique design shown in Fig.1 has been developed for the first step of the Fast Ignition Realization Experiment project at the Institute of Laser Engineering (ILE), Osaka University under bilateral collaboration between ILE and National Institute for Fusion Science (NIFS). The target consists of three parts; a low-density plastic (foam) shell with a plastic layer over-coated on it, a laser guide cone that guides a heating laser beam to the compressed fuel plasma and a fill tube. D_2 and DT fuel is fed through the fill tube and cooled down to liquid. The liquid fuel soaks the foam shell and is solidified. In the FY2008, following three important progresses were achieved.

Fabrication of 20-μm thick (Phloroglucinal carboxylic acid)-Formaldehyde shell

A new foam material of (Phloroglucinol carboxylic acid)-Formaldehyde (P-F) was successfully used to fabricate thin foam shells with thickness less than 20 μm. In order to fabricate the foam shell by O/W/O emulsion method, optimization of the viscosity of the solution is necessary to control the shell thickness. Various materials have been studied to fabricate thin foam shells [1]. The P-F solution was found to have enough high viscosity for thinner shell than 20 μm. Gelation process was improved and controlled the gelation time to fabricate uniform thin shell. It was also confirmed that the pore size of the P-F foam was decananometers, which was much smaller than that of previously used foam material of Resorcinol-Formaldehyde (R-F).

Leak check system for the targets

All the three parts of the target are glued by epoxy resin. Since the target is small and it is very difficult to handle it precisely, Leakage of the fuel gas through the joints would happen when the amount of the epoxy resin is not appropriate. On the contrary. the fill tube would be plugged if the epoxy resin is not properly spread and covers the tip of the tube. We developed a system to check the seal performance of target assembly by using an optical interferometer shown in Fig. 2. SF_6 is used instead of D_2 fuel because of its high refractive index and low permeability through the gas barrier. When SF_6 is loaded into the target, the optical path length that passes a target is longer than that of the evacuated target. The mount of the SF_6 inside the capsule is monitored by the interferometer. The validity of the system was experimentally confirmed by using a polystyrene shell as is shown in Fig. 3.

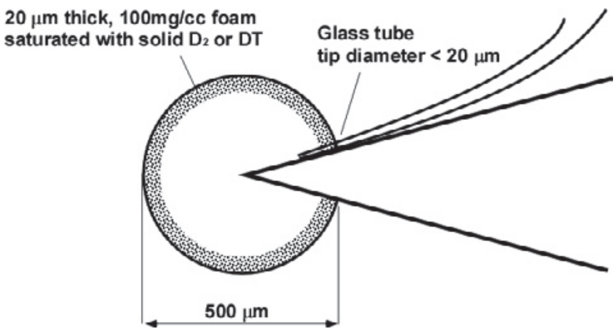

Fig. 1 Cryogenic foam target with gas barrier for FIREX-1

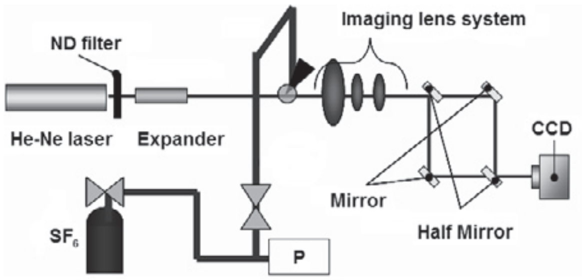

Fig. 2 A schematic drawing of an experimental set-up of interferometer.

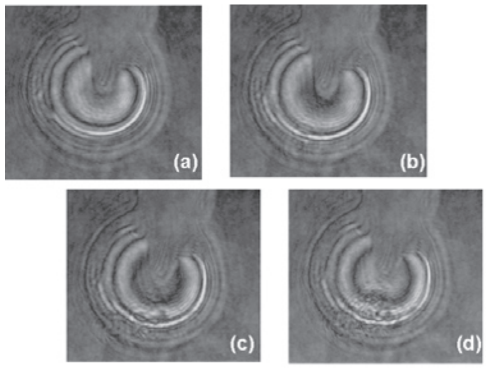

Fig. 3 (a) Interference images of a vacant poly-styrene shell target. (b) 0.2MPa of SF_6 gas was properly fed into the shell. (c) and (d) is in 6 and 12 minutes after feeding SF_6 gas. It was confirmed that there's no leak.

Temperature control for fuel layering

The foam shell has self-fuel-layering ability at a liquid state owing the capillarity of the foam material. For high density compression by implosion lasers, the fuel must be solid with a lower saturated pressure. The transition to a solid state will prevent a uniform layer formation because of random fuel crystallization and the density difference between liquid and solid. Application of the redistribution process in the fuel layering sequence was examined by calculating the temperature profile using a 2-D thermal transfer simulation code. It was found that volumetric heat by ortho-para conversion of 20% H_2 mixed in D_2 fuel was effective for the redistribution but temperature control of the cone guide with sub-nanowatt heat input was required to realize a uniform layer for the target of the present design.

[1] Yang, H., et al., Laser Part. Beams **26**, 449(2008).