A cryostat with optics windows for study of ICF cryogenics target

Liu Y., Zhu Y. Q., Jiang C., Zhou G.

Cryogenic Laboratory, Huazhong University of Science and Technology, Wuhan 430074, China

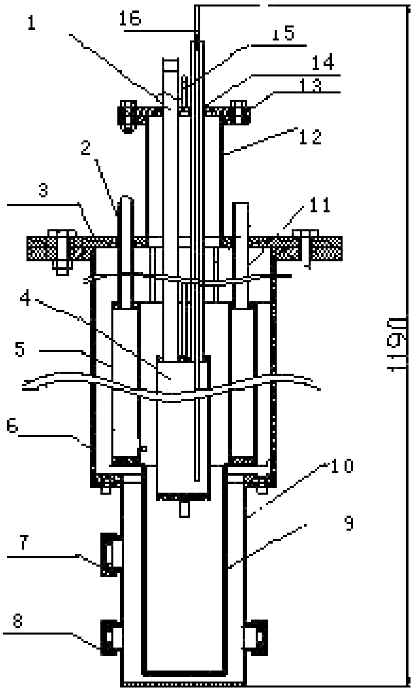
An optical cryostat used for fabricating inertial confinement fusion (ICF) cryogenic target is described. The cryostat holds a target cell. With the temperature control system, a desired thermal gradient vertically crossing the cell can be formed. The specifications of the optical cryostat are presented.

INTRODUCTION

Gravity can affect the distribution of the liquid fuel layer inside the target. This result the layer on the target's bottom is thicker than that on the top. In the ICF technology, one key is to produce a cryogenic target with an evenly distributed liquid fuel layer inside it. Utilizing thermal gradient vertically crossing the target to overcome the gravity is an effective method [1]. The manufactures of this kind of cryogenic target call for a cryostat of a special design, which must satisfy some requirements. First, it can provide a low-temperature environment within 10~40 K [2]. Second, it must hold a target cell, in which an ICF target can be loaded. Third, it must possess a temperature control system that can be utilized to create a desired thermal gradient vertically crossing the target cell. Fourth, it must have optical windows. Through these windows, holographic interferometer can be used to measure the distribution of the liquid fuel layer inside the target.

THE STRUCTURE OF THE CRYOSTAT

The cryostat diagram is shown in Figure 1. A liquid helium tank (4) is suspended from the upper flange of the cryostat by two thin-wall stainless steel tubes (Φ15×0.3 mm). One of these tubes is acted as liquid helium input pipe (1); the other is gaseous helium output pipe (14). The level detector (16) can be inserted into the tank through the output pipe. The liquid helium tank is enclosed by liquid nitrogen circular bath (5), which is hanged from the mid flange by four stainless steel tubes (Φ6×0.8 mm). By this way, the bath can decrease greatly the incoming radioactive heat from inner wall of the dewar flask to the liquid helium tank. The target cell can be set under the liquid helium tank. There is a device between the tank and the cell, which can be utilized to promptly adjust the position of the cell by three directions. With the refrigeration supplied by the helium tank, the cell can be frozen to a desired temperature. A copper screen (9) used to shield the target cell is connected with liquid nitrogen bath, and it is able to intercept radiation between the cell and dewar flask's inner wall. Of course, there are holes in the screen in order the light beam can go through. Three metal (1Cr18Ni9Ti) cylinders (12,16,10) comprise the dewar flask. Several windows are set in the lower part cylinder of the dewar. Some are used as optical windows (8) and another can be used as adjustment windows (7). The lower cylinder is connected with middle one by screws, so it is easy to be detached. This brings convenience to the replacement of the target. The dewar is a evacuated sealed body [3] Using high-vacuum, the dewar can seal a low-temperature environment in it.

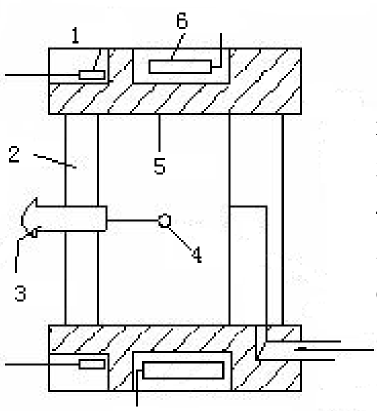


1. LHe input pipe
2. LN input pipe
3. mid flange
4. LHe tank
5. LN circular bath
6. mid cylinder
7. direction-adjust window
8. optical window
9. copper screen
10. lower cylinder
11. GN output pipe
12. upper cylinder
13. upper flange
14. GHe outlet pipe
15. GHe pipe to target cell
16. level detector

Figure 1 the cross-sectional view of the cryostat

TARGET CELL WITH TEMPERATURE CONTROL SYSTEM

The target cell is shown in Figure 2. The cell is an evacuated sealed body too. The walls of the cell are made of cryogenic glue. The target is placed near the center of the cell and horizontally supported by a thin glass fiber glued to the end of a nylon screw (3). The cell has two optical windows, so the measure light beam can go through. The top and the bottom of the cell are made of copper plates (5). Two heat conduct rods respectively connect these plates with the liquid helium tank. Each plate has a heater (6) and a temperature sensor (1) fitted into. The temperature sensor is Cryogenic Liner Temperature Sensor (CLTS). [4] Thus through controlling the electrical power of each heater, the refrigeration, which is conducted by heat conduct rod to each plate, can be adjusted respectively. If the sizes of these two plates are chosen properly, each plate can reach at a stable temperature desired.



1. temperature sensor
2. cryogenic glue
3. nylon screw
4. target
5. copper plate
6. heater

GHe

Figure 2 Cross-sectional view of the target-freezing cell

In the process of the experiment, gaseous helium (10^{-4}～10^{-5} Pa) as the heat exchange gas will be filled into the cell. Driven by the top plates temperature and the bottom’s, a stable thermal flux going through from the top to the bottom can be formed, thus a desired thermal gradient, which vertically cross the inner space of the cell, can be built.

SPECIFICATIONS

Capacity of liquid helium	0.9 L
Capacity of liquid nitrogen	4.3 L
Operating temperature	10K~40 K
The temperature gradient achieved	0~20 K/cm
Stability of operating temperature	±0.1 K
Power of the heater	0~10 W
Operating time	10 h

ACKOWNLEGEMENT

This work is supported by National Natural Science Foundation of China.

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