§15. Novel Approach to Form a Hydrogen Ice Layer for the FIREX Cryogenic Target

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i) Introduction

A typical FIREX target consists of a plastic shell, a gold conical laser guide and a glass fuel fill tube and is not spherical symmetric. To form a uniform fuel layer in the shell, target temperature control cannot be avoided because the conical laser guide plays a role of a heat exchanger. Some conical laser guide heating technique must be applied to control the target temperature. If the heating generates exceeded temperature gradient in the shell, solid fuel moves away from the conical laser guide.[1] It means the heating technique can be utilized as a heat source for fuel redistribution. Based on this concept, we consider a novel approach to form a hydrogen ice layer in the FIREX target. A unique layering sequence applying not the conventional heat source generated from fuel[2] but cone guide heating is proposed.

ii) Layering procedure

We propose the new layering procedure applying the conical laser guide heating technique. Figure 1 shows the schematic of the sequence. (Step 1) Liquid fuel is filled around the conical laser guide owing to its surface tension and then solidified. (Step 2) Solid fuel moving requires temperature gradient in the shell. We employed the laser heating technique as an external heat source. The conical laser guide is irradiated with laser light to provide a heat source. The solid fuel would sublimate around the conical laser guide and condense somewhere cooler. Under natural convection cooling, the small shell surface has uniform heat transfer. Therefore, the solid fuel could uniformly redistribute to the other interior of the shell. This process results in missing a solid fuel around the conical laser guide. (Step 3) After the redistribution, as temperature increases to the melting point, additional liquid fuel is supplied to the vacant space. This process time is as short as possible so that most of the solid fuel can survive. The Steps 2 and 3 are repeated until the completion to foam a required fuel layer.

iii) Layering demonstration

The new technique was experimentally demonstrated using surrogate fuel of H_2 in principle. Figure 2 shows the photograph layered H_2 ice in the dummy target with a 2 mm diameter PS shell. Thickness of the solid layer is 132~223 μm. Conspicuous variation is beside the conical laser guide, which might be caused by the surface energy variation in the LH_2 addition process. The inserted fill tube and applied glue must make the surface energy non-uniform. If the thinnest and thickest thicknesses, both locating around the conical laser guide, are ignored, the thickness variation is reduced to 155~192 μm. Defects on the interior surface are also estimated at the maximum of ~30 μm. This demonstration does not satisfy the required specification on the FIREX target at all. However, the conical laser guide heating technique has the possibility to realize a uniformly thick layer for a non-spherical symmetric target.

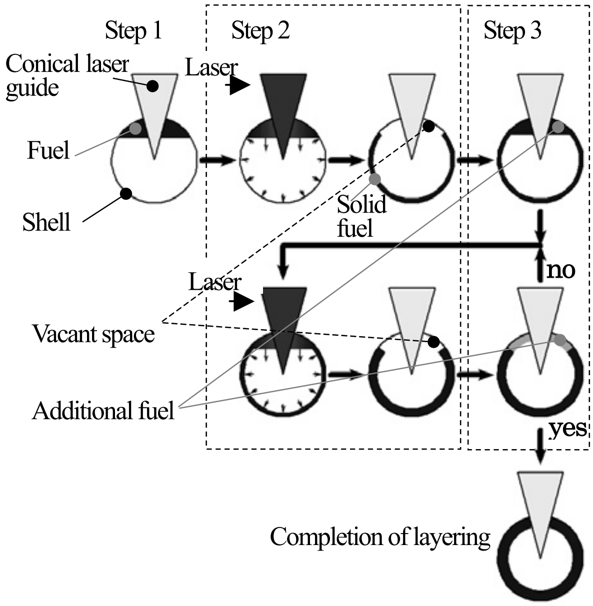

Fig. 1. Poroposed layering sequence applying the conical laser guide heating technique. During the sequence, the target is cooled by gaseous helium (GHe) with suitable temperatures for each step.

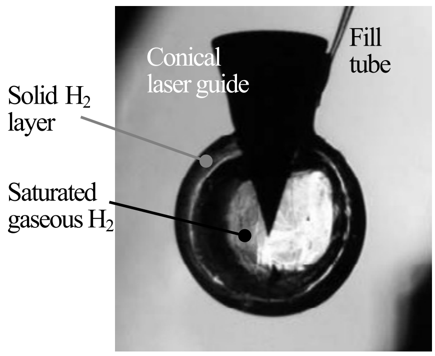

Fig. 2. Formed H_2 ice layer in the dummy target with 2mm diameter PS shell. GHe temperature was 13.10 K during the laser heating process.

1) Iwamoto, A. et al., *Fusion Sci. Technol*, **56**, 427 (2009).
2) Foreman, L. R., Hoffer, J. K., *Nucl. Fusion*, **28**, 1609 (1988).