§35. Study on Ablation of Liquid Wall in Laser Fusion Reactor Using Punched-out Targets

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Fast ignition scheme is very attractive because it employs compact lasers to achieve high gains. Introducing a liquid metal wall into a fusion reactor has several advantages including the realization of a compact reactor, good protection and rapid cooling of the wall. However, there are some difficulties associated with this arrangement. One problem is that the surface of the liquid wall is heated by alpha particles causing it to emit gas and particles. The emitted gas will degrade the vacuum, while some of the particles will hit the opposite liquid wall and generate secondary particles. These secondary particles may then give rise to other obstacles.

To investigate these processes, we performed experiments on ablation of the liquid wall. A lithium–lead liquid wall was used in a fusion reactor. In experiments, lithium was ignored because of its light weight. We used a punched-out target (POT) to simulate the emitted lead materials. The POT consisted of a glass plate with one side coated with lead. The thickness of the lead was 5 μm, which is the same as the alpha particle range in lead[1]. A laser beam irradiated the glass side of the POT. The interface between the glass plate and the lead was heated to generate plasma. Due to the high pressure, the rest of the lead was propelled forward.

Figure 1 shows a schematic diagram of this experiment. The coated lead was circular in shape with a diameter of 500 μm on the glass plate (referred to as a dot target). A Q-switched Nd:YAG laser was used to punch out the lead-coated targets. The pulse duration was 13 ns. The laser was focused on the lead dot targets with a spot size in the range 700–800 μm, making it larger than the target. The laser intensity was 4–5×10^8 W/cm^2. A green probe laser was focused to a line on the targets. A digital camera was used to measure the scattered probe light.

Figure 2 shows time-lapse images of the light scattered by the lead particles. The time resolution of each image was 7.5 ns. These images show that the propelled targets contain a lot of particles with diameters of the order of micrometers. The targets had velocities of about 500 m/s. From estimation, the speed of the lead particles was calculated to be about 700 m/s. The experimental result was in good agreement with the estimation result.

Figure 3 shows scanning electron microscope (SEM) images of particles captured on a glass plate placed 25 mm from the target. The diameters of the particles range from several tens of nanometers to several micrometers. Some particles with diameters of a few micrometers were observed. These results reveal that some particles are larger than the initial coating thickness. They may generate by secondary ablation from the opposite liquid wall.

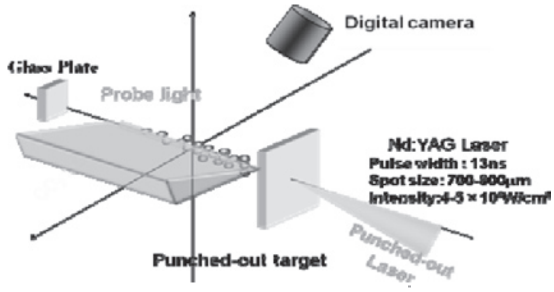

Fig.1 Experimental setup

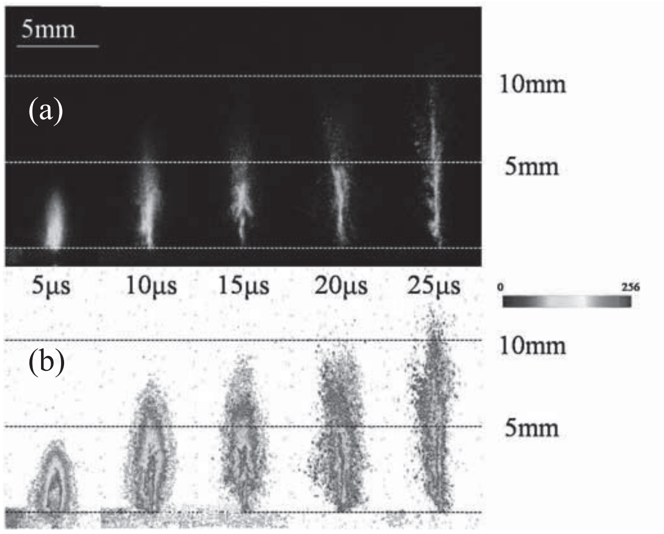

Fig.2 (a) Time-elapsed images of light scattering by lead particles.
(b) Intensity distribution of each scattering image.

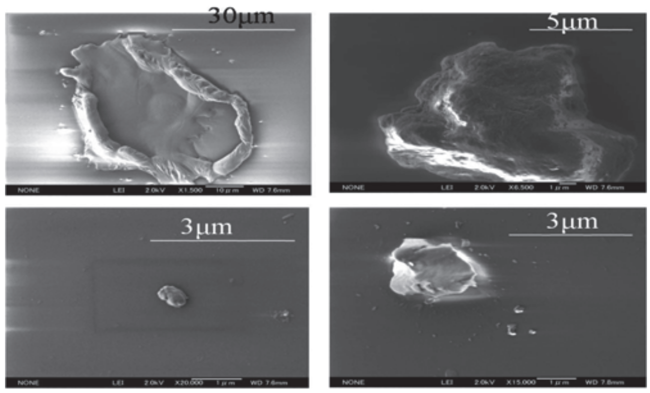

Fig.3 Scanning electron microscope (SEM) images of ablated particles captured on a grass plate placed 25 mm from the target.

1) J. F.Ziegler, "Helium: stopping powers and ranges in all elemental matter", Vol. **5,** (1980).