§35. Research on Ablation Process of Liquid Wall of Laser Fusion Reactor by Back-side Irradiation with Laser

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Fast ignition scheme is very attractive because it employs compact lasers to achieve high gains. The reactor do not need high vacuum condition, so its first wall will be made lithium-lead liquid metal. Having the liquid wall, it have advantage that the realization of small reactor and easy protection and cooling fast wall. On the other hand, there are some assignments, which should be considered. For example, vaporized liquid metal which is heated by alpha particles show how behavior and prevent recovering high vacuum, and so on.

Because of energy deposition by alpha particles which have Bragg peak, we think that vaporization starts the region of a certain level of depth. To estimate such kind of process, punched out target (POT) has been used. POT consists of a glass plate with coated lead. Laser irradiated from the glass side and was absorbed boundary between the glass plate and the coated lead. It was heated up, and generated high pressure. Then, rest of lead was propelled toward. Lithium was ignored because of light weight.

We calculated time profile of alpha particles which enter lithium lead flow. Alpha particles reached lithium lead flow 330 ns after irradiation, when chamber radius assumed to be 3 m. Ablation depth was roughly 4.3-6.0 μm which correspond to depth of its Bragg peak. Temperature reached over 2000 Kelvin (boiling point of lead). Deposited energy by alpha particles in the ablation region was about 0.56-1.12 MJ[1),2)]

Schematic diagram of this experiment is shown in Fig.1. Punched-out target was a round-shape coated Pb (Pb dot target) on a grass plate. In experiments, lithium was ignored because of its light weight. Dot thickness was about 4-6 μm and diameter was about 500 μm$^{\phi}$. Dot targets were used to prevent spreading, and heated by ceramic heater near the melting point of lead. A Q-switch Nd:YAG laser was used to punch out Pb dot targets (Punched-out laser). A pulse duration was 13 ns FWHM. The laser was focused on Pb dot targets whose spot size was 700-800 μm$^{\phi}$ larger than the dot diameter. The laser intensity was 4-10$\times 10^8$ W/cm^2.

Green probe laser was line focused to the targets. Scattering light detected with CCD camera at 90-degree scattering angle.

Fig.2 shows scattering images that temporal progressing of ablation plumes and its intensity distributions. Dot thickness was 6 μm and the laser intensity was about 8-9$\times 10^8$ W/cm^2. Time resolution of each picture was 7.5 ns. These images showed that targets propelled toward without large divergence angle.

We estimated flying velocities of the plume center and diverging angles by Fig.2.

Center velocities were estimated about 230 m/s and diverging angles were about 7.9degrees.

In addition, we measured the particle-size distribution of the ablated plume. Fig.3 was number-size distribution if the particles were spherical. Because of spatial resolution, up to the sub-micron order particles were not detected. And the particles with longer diameter than the target thickness were detected, it was assumed that the part of the particles stay in solid or liquid propelled rotating or deforming.

From experimental result, we found that the flying to the reactor core direction of the high density region include many large-diameter particles can be decreased by repeated structure to tilt the reactor wall more than 8 degrees. Then, we observed that the ablation plumes have enough velocities to reach the opposed wall by next shot if the radius of reactor were 3m and the pulse repetition frequency was 4 Hz.

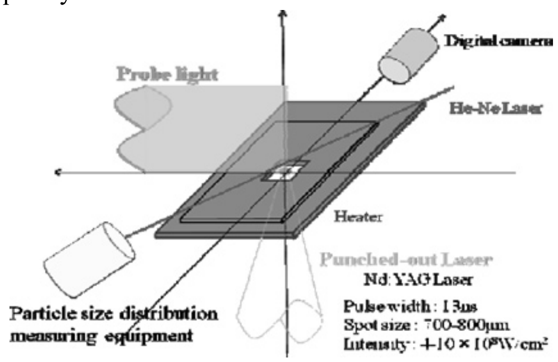

Fig.1 Experimental setup

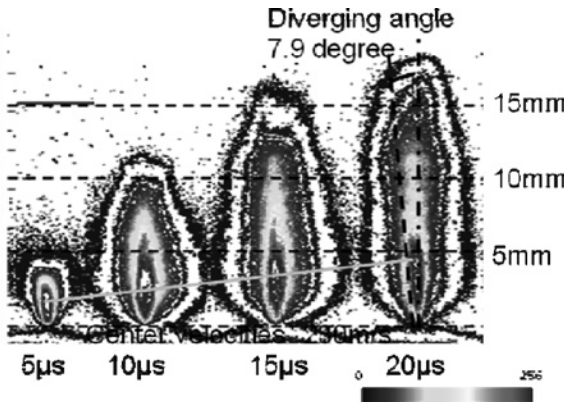

Fig.2 Density distribution that temporal progressing of ablation plume

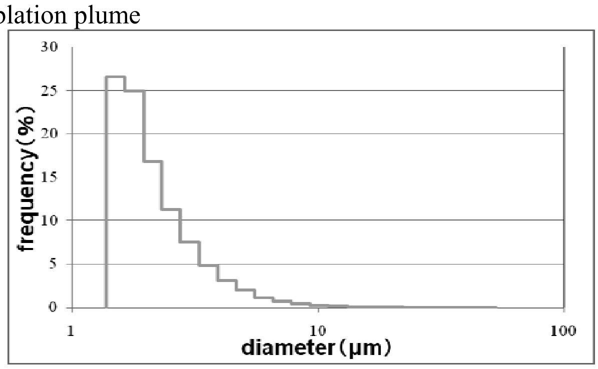

Fig.3 Particle number-size distribution of ablation plume

1) T.Johzaki, IFE Forum(2006)115.
2) J. F.Ziegler, Stopping Powers and Ranges in All Elements, volume5 (1980).