§35. Research on Dynamics of Ablated Vapor from Liquid Wall in Laser Fusion Reactor

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In future laser fusion reactor, liquid first wall is an attractive concept to protect the structural material from high intensity heat load and target debris. The alpha heating is the most critical element in the heat load because of its shot range in the wall material. Our conceptual design reactor KOYO-F uses liquid LiPb as the first wall. The fusion yield of KOYO-F is 200 MJ/shot at 4 Hz. The Chamber radius is 3 m and the thermal load on the inner surface is 0.35 MJ/m^2 and the peak intensity is 2 x 10^{12} W/m^2. In the KOYO-F design, 10kg of LiPb is vaporized and then condenses on the other side wall due to cryogenic effect. It was found that evacuation time based on the cryogenic model was 200 ms including gas dynamics in the chamber and thermal conduction in the wall[1].

However, this model does not include generation of aerosols and micro particles. For example, alpha particles release its kinetic energy when they stop. As the result, temperature takes its highest value at 8 μm deep from the surface. As the result a thin film of liquid LiPb pealed off and breaks into small particles due to hydrodynamic instabilities.

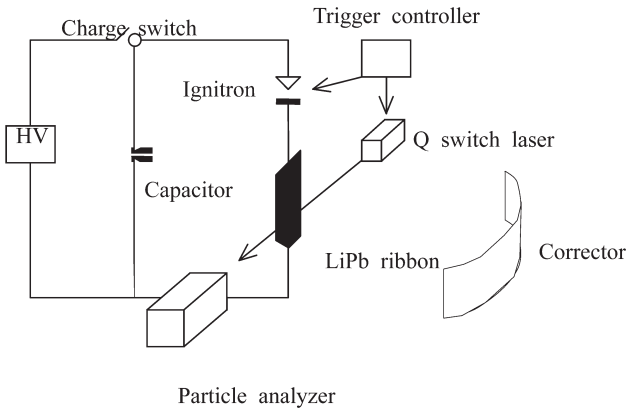

Fig. 1 Experimental equipment to simulate ablation by alpha particles.

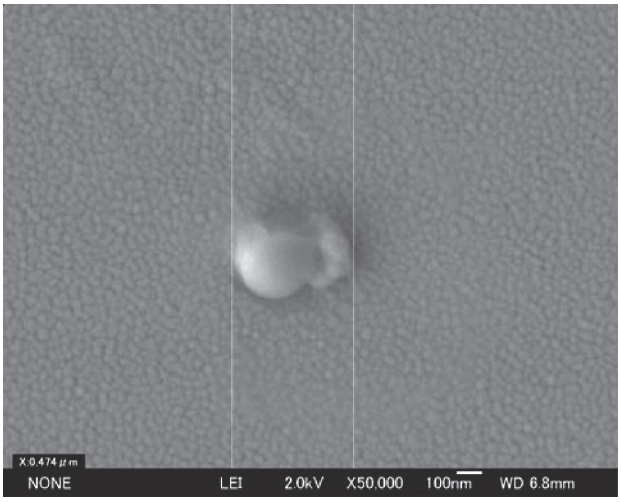

Fig. 2 30 nm diameter aerosols and micro particle at the center.

In the past experiment, laser heating from the surface was used to discuss the formation of aerosols. However, this type of experiment is very hard to experimentally simulate above mentioned ablation due to alpha heating. After the laser irradiation, relatively high temperature, low density plasma is formed at the critical point and the surface is heated from the surface by heat conduction.

We are going to use discharge method along a multi-layered ribbon target with different electrical conductivity. The experimental equipment are illustrated in Fig. 1. The ribbon target is instantaneously heated by electrical current from the capacitor. Stored energy in the capacitor is set to 0.35 MJ/m^2 that is the alpha particle load on the first wall of the actual reactor. The vaporized metal makes aerosols during adiabatic expansion and deposits on the corrector.

Figure 2 shows corrected aerosols and micro particles that would be formed in different process. The size of aerosols is very close to a calculated result based on Lukyanchuk Zeldovich-Raizer Model.[2]

In 2007, multi-layered targets will be used to simulate ablation by alpha particles.

References

[1] Y. Kozaki, et.al., 18th IAEA Fusion Energy Conference Sorrento, Italy, 4 to 10 October 2000, IAEA-CN-77/FTP1/27

[2] B. S. Luk'yanchuk, W. Marine, S. I. Anisimov, and G. A. Simakina, SPIE 3618 (1999) 434-452.