§27. Simulation Study of Chamber Evacuation Dynamics of Laser Fusion Reactor

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One of the critical issues of a laser fusion reactor with a wet wall is the chamber clearance. After micro explosion with 100 MJ nuclear yield, 10 kg of liquid metal evaporates from the surface due to heating by α particles, ions and debris from the target. Contribution of x-ray on the ablation is negligible in the case of direct drive implosion[1]. The evaporated plume makes, then, mist and clusters after expansion cooling. Such clusters would attach on the injected target surface and degrade the target performance through RT instabilities and preheat of the fuel. Another concern is the influence on the propagation of laser beams.

To experimentally simulate the ablation process, laser irradiation is often used. We, however, found that ablation process by ions is quite different from that by lasers. The range of α particles in liquid Pb is about 10 μm. As the result, superficial liquid Pb evaporates as a high density, low temperature, plasma with low ionization rate. In our preliminary estimation, the plume becomes clusters within a few cm flight after ablation. Formation of clusters in a laser-ablated plume is studied extensively by Yabe and Luk'yanchuk through simulation and experiment [2, 3]. They found that the experimental result agreed well with simulation.

In this study we numerically evaluated the formation of clusters in the ablated plume in a laser fusion reactor basing on Luk'yanchuck, Zeldovich-Raizer model[3].

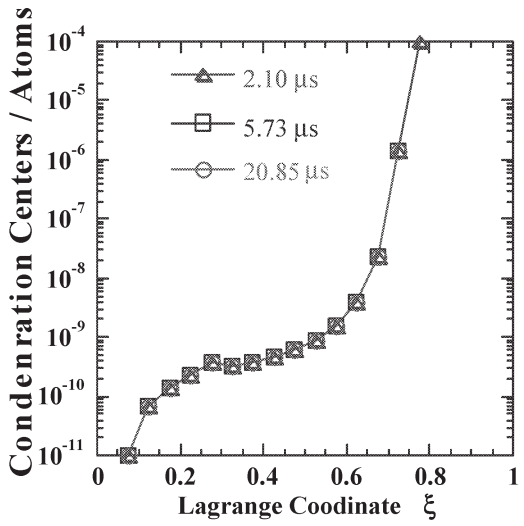

Fig. 1 Condensation centers per atoms of vapor.

The simulation code is written for spherically symmetric, isothermally expanding plasma including physics of 1) condensation, 2) kinetic equation, 3) kinetics of cluster growth, 4) adiabatic equation, 5) size distribution function for nano clusters. Figure 1 shows condensation centers per atoms of vapor.

Figure 2 shows temporal change of clusters in the plume. Figure 2 indicates that nano clusters less than 250 nm diameter are formed in the plume.

In order to discus the influence of these clusters on the target performance and beam propagation, we had to consider whole dynamics of ablated vapor. Since the initial velocity of the ablated vapor is 140 m/s. If there is no collisions with ablated vapor from the other inner surface, these clusters would directly condense on the other inner surface and disappear before the next laser irradiation. Numerical evaluation on these process is the next work.

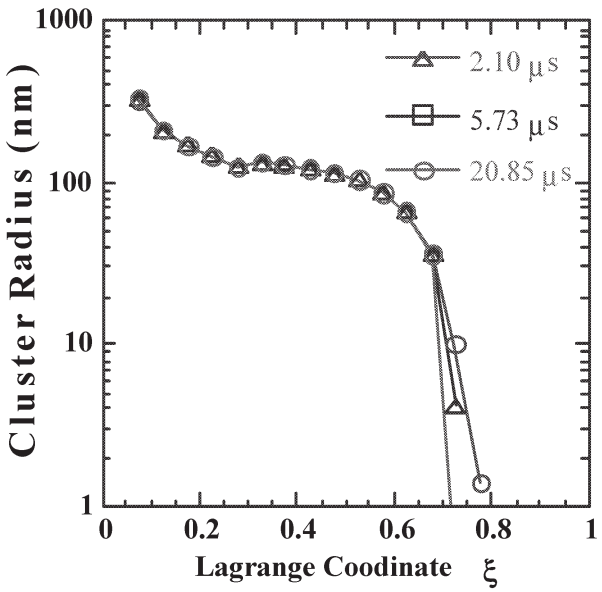

Fig. 2 Temporal change of clusters in the plume.

References

1) H. Furukawa, Y. Kozaki, K. Yamamoto, T. Johzaki, and K. Mima ; submitted to Fusion Engineering and Design(2004).
2)Masahiro Kuwata, B.S. Luk'yanchuk, and T. Yabe ; Jpn J. Appl. Phys. 40 (2001) 4262 – 4268.
3)B. S. Luk'yanchuk, W. Marine, S. I. Anisimov, and G. A. Simakina, SPIE **3618** (1999) 434-452.