§38. Dynamics of Ablation Plumes Produced by Fusion Products in Laser Fusion Liquid Wall Chamber

Norimatsu, T. (Osaka Univ.),
Furukawa, H. (Inst. Laser Tech.)

One of the critical issue of a laser fusion reactor with a liquid wall is the chamber clearance. After micro explosion with 100 MJ nuclear yield, about 10 kg of liquid metal evaporates from the surface due to heating by α particles, ions and debris from the target. 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.

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 this study, we have developed an integrated ablation simulation code DECORE (Design Code for Reactor) to clarify the ability of the chamber clearance. In this integrated simulation code, effects of condensation of a plume, the formation of clusters in the ablated plume, phase transition from liquid to neutral gas to partially ionized plasma, absorption of energies of charged particles, equation of state, hydrodynamics, and radiation transport are included.

Characteristics of a plume produced by ablation in liquid wall chamber of KOYO-fast have been analyzed. A plume produced by ablation moves with velocities of a few km/s. Formation of clusters in a plume with hydrodynamic motion is carried out.

A new model on stopping power in high Z and low temperature plasmas has been developed in this study. Electrons in metal consists of conduction electrons, resonance electrons, and bound electrons. Resonance electrons behave like free electrons due to physical phenomena. Resonance electrons are obtained by functions of binding energy, population, and energy of incident charged particles.

Figure 1 shows temperature, number density and velocity profiles of lead. As shown in Fig. 1, ablated lead moves as a clump with velocities of a few km/s. To estimate this velocity is very important for analysis of protecting beam port from charged particles.

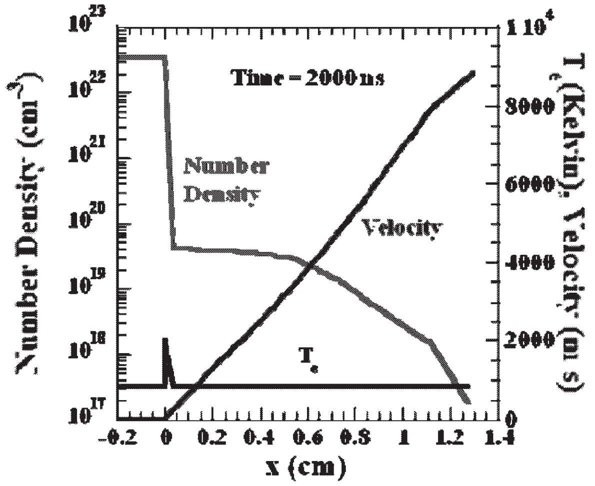

Fig. 1 Temperature, number density and velocity profiles of lead.

Fig. 2 shows profile of diameter of clusters and number density of clusters. Diameter of clusters in a plume in liquid wall chamber of KOYO-fast is mainly 50 nm. This result is in good agreement with experimental results[1].

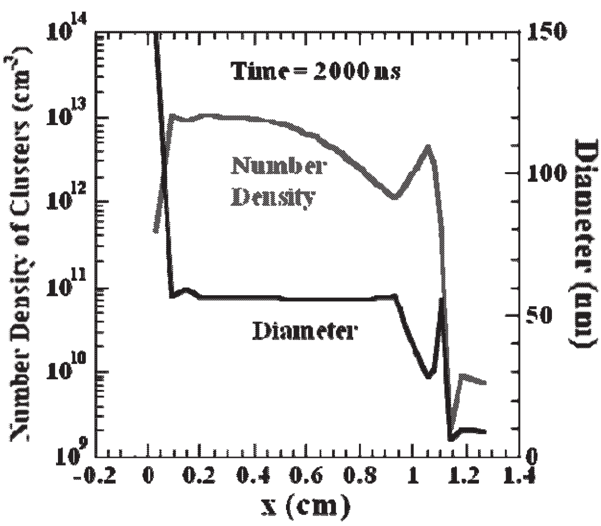

Fig. 2 Profile of diameter of clusters and number density of clusters.

This subject is the first step to estimate collisions between plumes produced by ablation near the center of the liquid wall chamber. Collisions between plumes strongly affect a design of laser fusion reactor.

[1] Ohshige, T., et. al.; IFSA2007 Proceeding, IOP Publishing, Journal of Physics: Conference Series **112** (2008) 032040. http://iopscience.iop.org/1742-6596/112/3/032040/