§12. Study on Vapor Shielding Effects under High Temperature and Particles for Nuclear Fusion Reactor

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Critical issue in designing an advanced fusion reactor with high output energy density is the ablation of the hot first wall exposed by energetic particles from plasma. In a case of a dry wall reactor for laser fusion operated with a 150 MJ yield target, the total thermal load on the surface is estimated to be 4.5 x 10^{18} W/cm^2, which heats the initially 500°C tungsten surface to 3000°C at the chamber radius of 6 m [1]

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 solid Tungsten is roughly 10 μm. As the result, tungsten evaporates as a high density, low temperature plasma with low ionization rate or neutral gas. One of aims of our study is to clarify vapor shielding against incident energetic charged particles.

In this study we have developed an integrated ablation simulation code DECORE[2,3] (Design Code for Reactor). We estimate temperatures, densities, and velocities of ablated lead (liquid wall material) using DECORE for the case of first ignition with 200 MJ power output[2,3].

Figure 1 shows the schematic diagram of DECORE. As shown in Fig. 1, DECORE consists of atomic process code, stopping power code, EOS code, emissivity and opacity code, and ablation code.

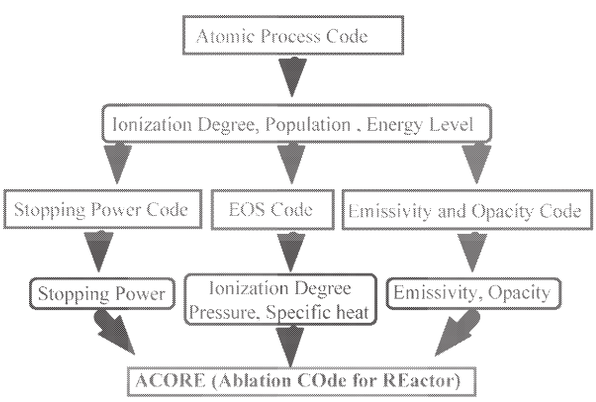

Fig. 1 Schematic diagram of DECORE.

Figure 2 shows number density and velocity profiles of lead. As shown in Fig. 2, ablated lead moves as a clump with velocities of a few hundred m/s.

Figure 3 shows temperature profiles of lead. For these temperature, ablated lead may condensates and a lot of nano clusters may exist in lead plume.

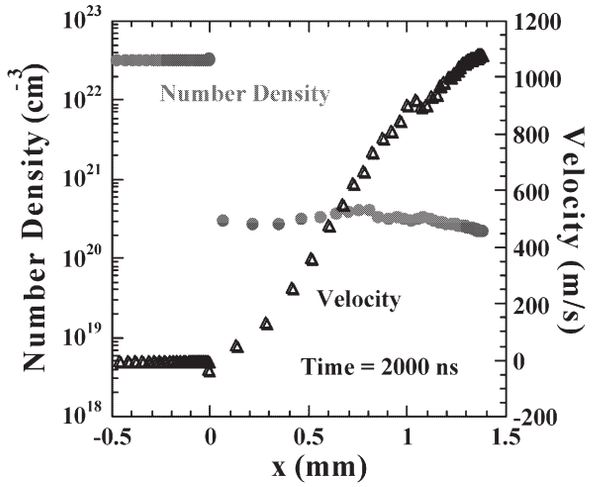

Fig. 2 Number density and velocity profiles of lead. Locations -0.5<x<0 and 0<x mean liquid and vapor phases, respectively.

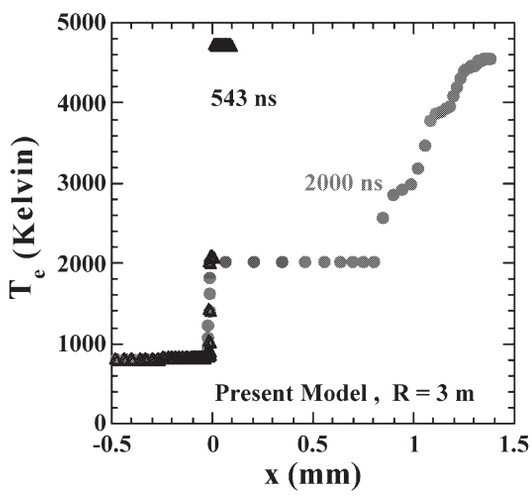

Fig. 3 Temperature profiles of lead.

References

[1] A. R. Raffray et al., Presented at ISFNT-7, May 22-27 (2005) Yokohama, Japan.
[2] H. Furukawa, Y. Kozaki, K. Yamamoto, T. Johzaki, and K. Mima ; Fusion Engineering and Design**73** (2005) 95-103.
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