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§25. Aerosol Formation and its Effects on the Chamber Wall Lifetime and Operation of IFE Power Reactors

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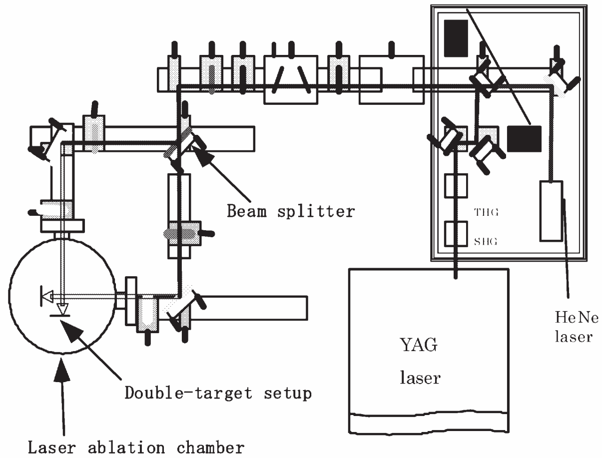
It is well known that along with DT-pellet implosions, IFE reactor chamber wall components will be exposed to repeated short-pulses of 14 MeV neutrons, intense X-rays, high-energy unburned fuel particles and pellet debris such as CD complex ions. As a result, wall materials will be subject to ablation, but re-deposition of ejected materials may occur at the same time. These processes will directly affect the lifetime of wall components and perhaps the implosion pulse frequency, i.e. reactor power output, as well for the reason to be mentioned next.

Whether the wall surface material is a solid or liquid, one predicts some aerosol formation in the chamber periphery region where ejected material flows cross over each other, leading to local density maxima. In addition to this, aerosol formation is also possible at the center of symmetry of a reactor chamber if it is in the form of sphere or cylinder.

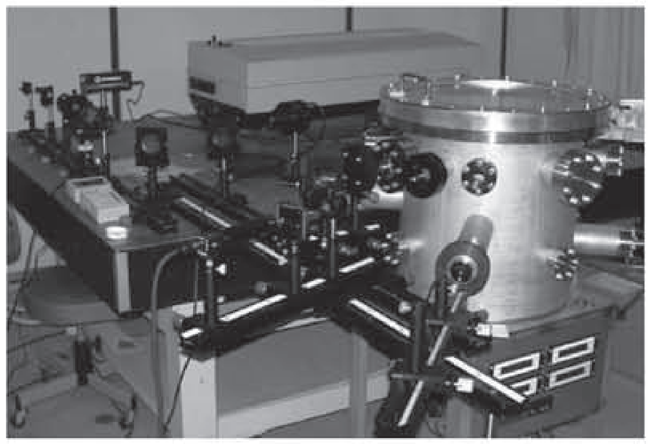
Depending up on the collision conditions of ejected materials, the size of aerosol particles to be formed at the center may increase by coalescence, but can decrease by disintegration. As such, aerosol formation will occur in a yet-to-be explored manner. Importantly, either way the air-borne time can be orders of magnitude longer, compared with that for direct re-deposition, due to the loss of momentum.

These air-borne aerosol particles are likely to absorb or reflect the subsequent laser beams intended for implosion, affecting directly the reactor power output. It follows from these arguments that the pellet implosion frequency must be controlled to avoid the aerosol effects. Despite its critical importance, this technical issue has not yet been clearly addressed in the IFE research community.

The present work is intended to investigate the behavior of aerosol formation from ablated materials in the center of symmetry of an IFE reactor chamber. As shown in Fig. 1-(a) and (b), a laboratory experimental setup has been put together for this purpose. A high-power (~1J) pulse-operation (~50ns, 10Hz) YAG laser beam is employed for the primary materials ablation. This laser beam is first split and then reshaped to have a rectangular cross-section to radiate two targets, as shown in Fig. 2. Selected as the target materials are lithium, lead, and their alloys. Currently, this dual-target laser ablation setup is being installed with a turbo-molecular pump system to prepare for actual experiments.



(a)



(b)

Fig. 1 A schematic diagram of the laser-ablation experimental setup (a), and a close-up on the ablation chamber (b).

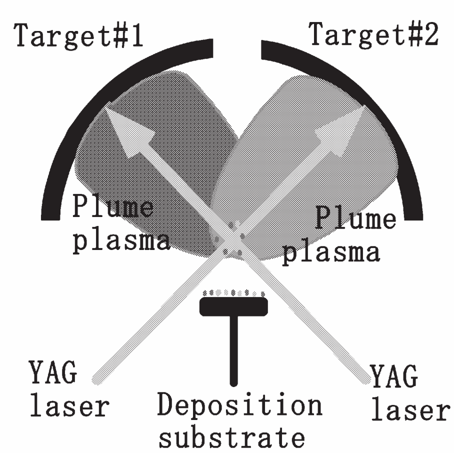


Fig. 2 A schematic diagram of the dual-target experimental setup for aerosol formation due to ablation plume-to-plume interactions.