§36. Laboratory Experiments on Aerosol Formation by Colliding Ablation Plumes (LEAF-CAP)

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It is predicted that, along with DT-pellet implosions in inertial fusion power reactors, chamber walls will repeatedly be exposed to intense pulses of 14MeV neutrons, X-rays, high-energy unburned fuel particles and pellet debris such as hydrocarbon ions. As a result, wall materials will be subjected to thermo-physical erosion due to evaporation, sputtering and ablation, etc. Eroded materials will either be re-condensed elsewhere on the wall after travelling across the chamber or collide each other perhaps in the periphery and in the center or on the axis of symmetry to form nano-clusters which may grow into aerosol, floating until it is pumped out. These processes directly affect the wall lifetime and reactor operation in terms of pulse frequency because laser beams can be reflected by floating aerosol, which then hinders subsequent pellet implosions. Despite its critical importance, this chamber clearing issue has not yet been addressed in the IFE research community.

The present work is intended to investigate fundamental aspects of laser-induced materials ablation behavior with the particular emphasis on aerosol formation by colliding plumes. A new experimental setup shown in Fig. 1 has been put together for this purpose and is named LEAF-CAP for the Laboratory Experiments on Aerosol Formation by Colliding Ablation Plumes. Employed in this setup is a YAG laser beam (1.2J/pulse, 6ns, 10Hz), converted into the third harmonic (355nm), which is optically split into two equal-power beams and then each line-focused (0.1cm x 1cm) to radiate two targets at room temperature in a vacuum chamber (10^{-6} Torr), i.e. a double target setup. These targets are in the form of rectangular disk (5cm x 1cm x 0.5cm), but arc-machined on the beam-facing side, and are positioned in such a way that two ablation plumes would collide each other at the center of the arc curvature, as shown in Fig. 1. Used as targets in these LEAF-CAP experiments are copper, aluminum and carbon.

A comparison between the single and double target laser ablation experiments in the case of copper is shown in Fig. 2. One immediately recognizes that the ablation plume, emitting Cu-I and Cu-II lights, in the single target setup (Fig. 2-(a)) extends longer than that seen in the double target setup (Fig. 2-(b)). Aluminum plumes have exhibited similar behavior. It follows from theses observations that recombination followed by relaxation takes place due to the collision of ablation plumes. In the case of carbon, rather strong Swan band radiation has been observed in the colliding center, as shown in Fig. 2 (d), suggestive of C_2 formation. To corroborate this, as shown in Fig. 3, direct mass spectrometry has identified species corresponding to m/e=12 for C^+, 24 for C_2^+, 36 for C_3^+ and 48 for C_4^+. This clearly indicates the formation of carbon nano-clusters by colliding ablation plumes. Detail analysis on these data is under way.

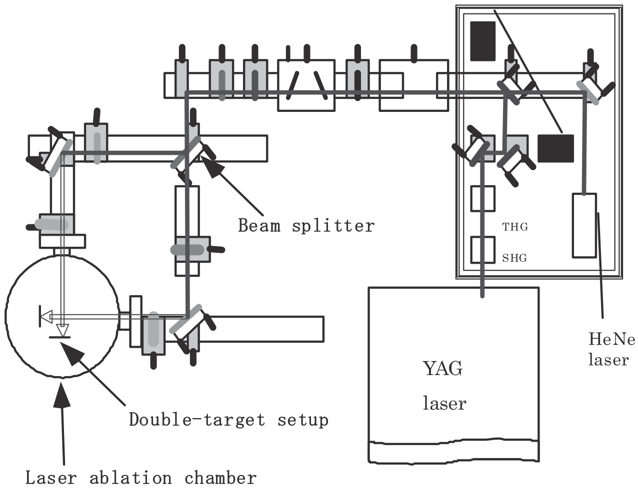

Fig. 1 A schematic diagram of the LEAF-CAP facility.

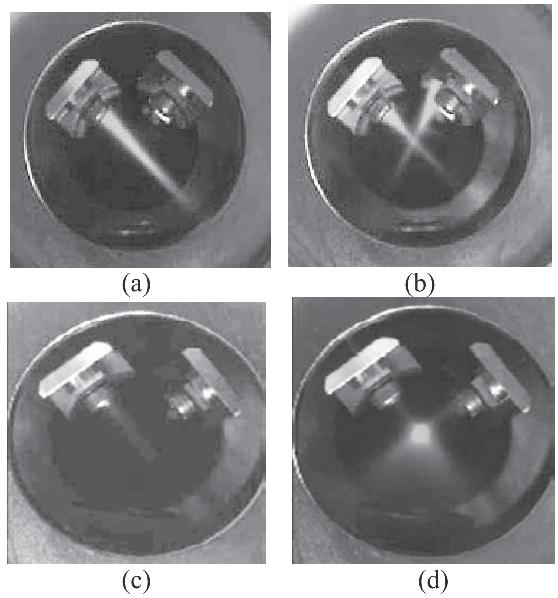

Fig. 2 Laser ablation plumes; (a) single Cu-plume; (b) colliding Cu-plumes; (c) single C-plume; and (d) colliding C-plumes.

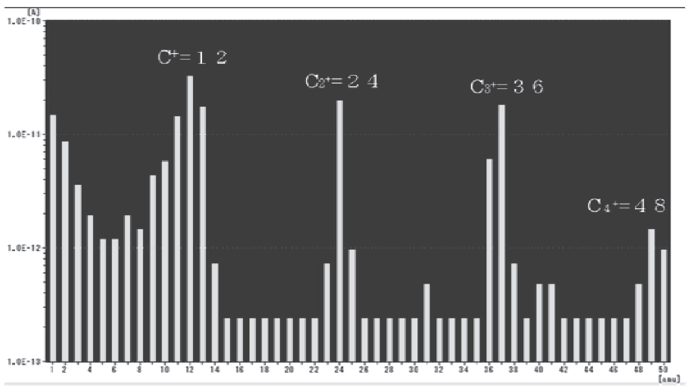

Fig. 3 Mass spectra observed for colliding plumes of carbon in the LEAF-CAP facility.