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

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It is predicted that, along with pellet implosions in inertial fusion power reactors, target chamber wall components will repeatedly be exposed to intense pulses of 14MeV neutrons, X-rays, high-energy unburned DT-fuel and He ash 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 will collide with each other perhaps in the center or on the axis of symmetry region to form aerosol, floating until it is pumped out. These processes directly affect the wall lifetime and also pulse repetition rate because laser beams can be reflected by floating aerosol, which then hinders pellet implosions. Despite its critical importance, the chamber clearing issue has not yet been addressed in the IFE research community.

The present work is intended to investigate fundamental aspects of aerosol formation by colliding plumes. A schematic diagram of the LEAF-CAP facility [1] is shown in Fig. 1. Employed in this facility is a 3-ωYAG laser (1.2J/pulse, 6ns, 10Hz, 355nm), which is split into two equal-power beams and then line-focused to irradiate two targets, i.e. a double target setup. Targets are arc-shaped on the laser-facing side in such a way that two ablation plumes would collide with each other in the center-of-arc region. Used as targets in these LEAF-CAP experiments are copper, aluminum, carbon and tungsten.

Typical images taken from the single and double target experiments conducted for tungsten and carbon are shown in Fig. 2. Notice the difference in plume colliding behavior: tungsten plumes appear to penetrate each other whereas carbon plume exhibits Swan band radiation, suggestive of C_2, in the center-of-arc region. Mass spectra taken from colliding carbon plumes are shown in Fig. 3, indicating cluster ions including: C_2^+, C_3^+, C_4^+, C_5^+, and C_6^+. It is highly possible that these clusters grow into aerosol, perhaps in the form of carbon nano-tubes.

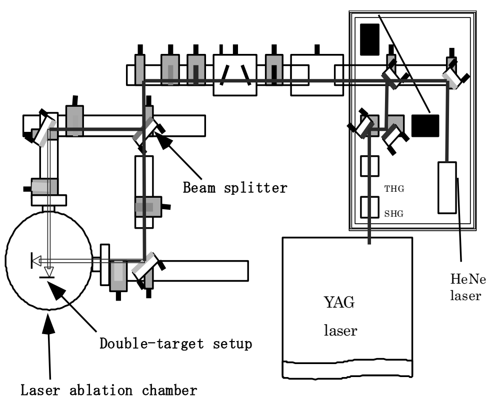

Fig. 1 A schematic diagram of the LEAF-CAP facility.

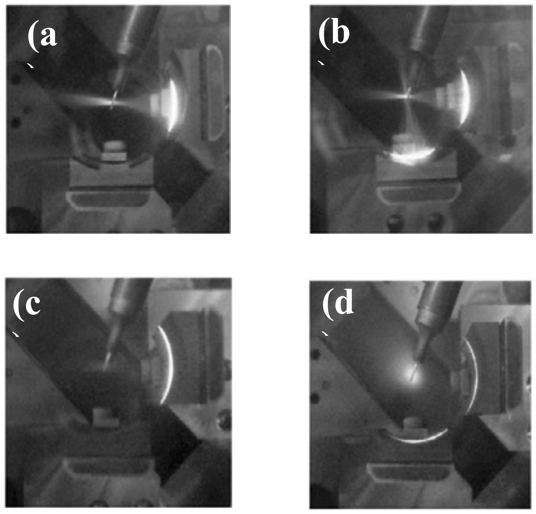

Fig. 2 Laser ablation plumes; (a) single W-plume; (b) colliding W-plumes; (c) single C-plume; and (d) colliding C-plumes, all generated at 4.2 J/cm^2/pulse [2].

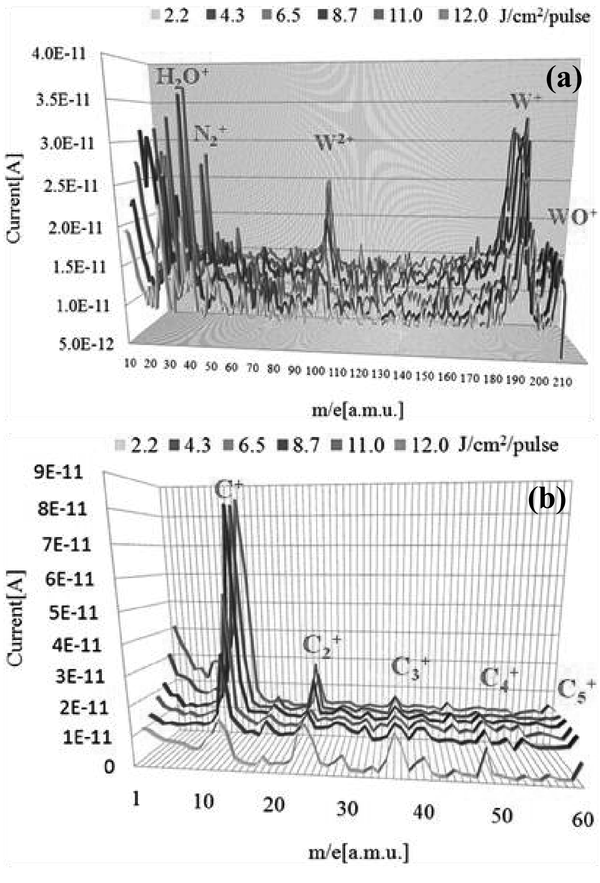

Fig. 3 Mass spectra observed for colliding tungsten and carbon plumes in the LEAF-CAP facilit [2].

[1] Hirooka, Y. et al. “Laboratory Experiments on Aerosol Formation by Colliding Ablation Plumes”, paper presented at IFSA2009, Sep. 6-10th, 2009, San Francisco (to be published in J of Phys. Conf. Ser. 2010).
[2] Sato, H. et al. “Dynamics of colliding ablation plumes”, paper presented at APFA2009, Oct. 27-30th, 2009, Aomori (to be published in JPFR 2010).