§32. Aerosol Formation and Hydrogen Co-deposition by Colliding Ablation Plumes

Hirooka, Y.,
Tanaka, K.A., Yabuuchi, T., Shibata, R., Hayashi, Y. (Osaka Univ.)

It is predicted that, along with pellet implosions in a high-repetition rate inertial IFE reactor, the interior of target chamber 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 with the total power deposition reaching of the order of 10J/cm^2/pulse,.

As a result, wall materials will be eroded by various thermal and physical processes, including evaporation, sputtering and ablation (the ejection of materials in the plasma state), etc. Some of the eroded materials may collide with each other perhaps in the center of symmetry region of target chamber to form aerosol, which can then scatter laser beams, affecting the subsequent implosions.

On the other hand, materials that are not associated with aerosol formation will be re-deposited elsewhere after travelling across the chamber, which extends the wall lifetime. However, it is also possible that tritium may continuously be incorporated into these re-deposits, leading to the radio safety problem. Despite their importance, the aerosol formation and tritium build-up issues have not yet been addressed in the IFE research community.

In our previous work [1,2], some of the fundamental aspects of aerosol formation by colliding ablation plumes were investigated, using the LEAF-CAP setup shown in Fig. 1 [1] in which targets are irradiated by 3ω–YAG laser at 10Hz, each 6ns long, at power densities up to ~30J/cm^2/pulse. The present work is intended to investigate more details of hydrogen co-deposition behavior. Employed as the target samples are carbon (isotropic graphite), lithium and lead, all first wall candidates.

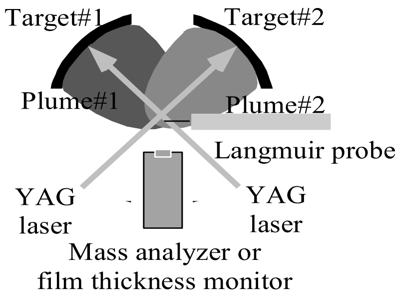

Fig. 1 The LEAF-CAP setup [1].

Shown in Fig. 2 are visible spectra taken from colliding ablation plumes of carbon in the LEAF-CAP setup. Recognize that there is a strong radiation due to the Swan band, indicative of the formation of C_2 and/or C_2^+. Also, it has been found that not only C_2 but other cluster ions are formed, including C_3^+, C_4^+, and C_5^+, as shown in Fig. 3. This implies that even larger cluster can be formed in colliding plumes. Interestingly, the deposits on a Pyrex glass substrate set at the position for the mass analyzer (see Fig. 1) contains a variety of nano carbon materials such as those shown in Fig. 4. Currently, an atomic and molecular reaction model is being put together to describe the formation mechanism of nano-size carbon aerosol in the LEAF-CAP setup.

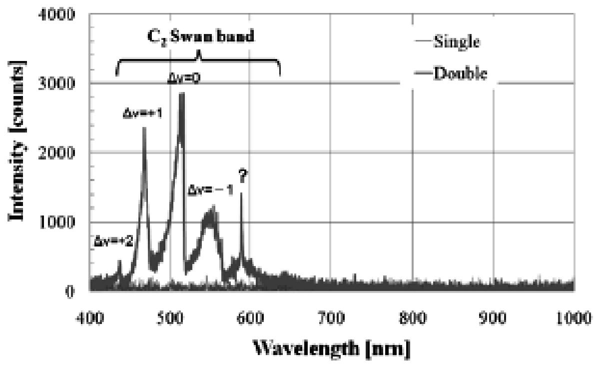

Fig. 2 Visible spectra taken from colliding ablation plumes of carbon [1].

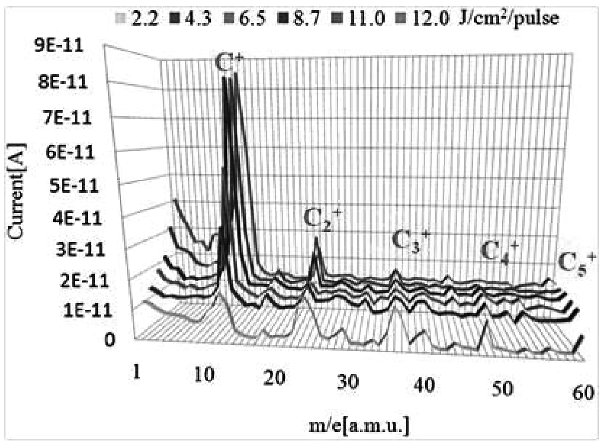

Fig. 3 Ion mass spectra of colliding carbon plumes [3].

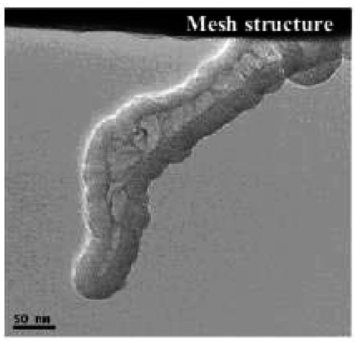

Fig. 4 A carbon nano structure formed in colliding carbon plumes[2].

[1] Hirooka, Y. et al. J. Phys. Conf. Ser. 244(2010)032033.
[2] Hirooka, Y. et al. Fusion Sci. Technol. 60(2011)804.
[3] Sato, H et al. J. Fusion Plasma Res. Ser. 9(2010)432.