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Formation of Aerosol in an Inertial Fusion Reactor I ~Model Experiment with Laser Plasma~

レーザー核融合炉内でのエアロゾル形成I ~レーザープラズマによるモデル実験~

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In a 10Hz-repetition inertial fusion reactor, high-energy particles along from fusion pellet implosion bombards the reactor wall. Wall materials may ablate and collide at the center of the reactor, and is likely to form an aerosol. We simulated the collision of carbon ablation plasma generation of the aerosol by using laser ablated plasma as a model experiment. We compared differences of aerosol formation due to the way of a collision, right angle and head-on carbon targets. When ablated plume colliding from the opposite direction, it was found a possibility the aerosol was generated larger and longer.

1. Introduction

In inertial fusion reactor to perform 10Hz repetition using a short-pulse laser, high-energy particles bombard the reactor wall [1]. The wall materials may ablate and come together at the central region of the reactor. The ablated plumes collide with each other, and are likely to form an aerosol. If aerosol formed, the intense laser beams may be scattered. Therefore, for the model experiments of aerosol formation in the inertial fusion reactor, we compared the differences in aerosol formation in the collision of two ways of ablation plasma; one at right angle and the other at head-on collisions.

2. Experimental

This experiment used a scheme, so called Laboratory Experiments on Aerosol Formation by Colliding Ablation Plumes (LEAF-CAP) proposed by Hirooka [2]. Third harmonic of converted YAG laser (wavelength 355nm, pulse length 6nm) was divided into two beams by a half mirror, and was line focused to 10mm by 0.1mm by cylindrical lenses each at beam. Two carbon curved targets were irradiated by these two UV laser beams. Ablation plumes collided with the target center of curvature. Laser energy density was 10J/cm^2/pulse in this experiment.

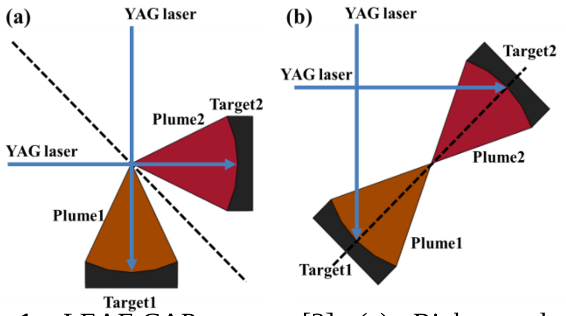

Fig.1. LEAF-CAP setup [2] (a) Right angle collision (b) Head-on collision

As shown in Figure 1, two different configurations were taken to see the difference of colliding plumes. One of the arrangements is right angle targets, and another one is head-on collisions.

First, Langmuir probe measurement was performed to investigate the plasma electron density and temperature from the single target in the two arrangements. The results are shown in Table I. At the right angle arrangement, electron density was 1.4×10^{10}/cc, and electron temperature was 1.7 eV. At the head-on arrangement, electron density was 1.7×10^{10}/cc, and electron temperature was 2.1 eV.

Next, spectroscopy was performed using a spectrometer to determine the spectral components of plasma self-emission of the ablation plume at colliding point. The integration time of this spectroscopy was 100 msec. the results are shown in Figure 2. Both of arrangement had components

Table I. Langmuir probe measurement of two arrangements of the single target.

	Ne (/cc)	Te (eV)
Right angle	1.4×10^{10}	1.7
Head-on	1.7×10^{10}	2.1

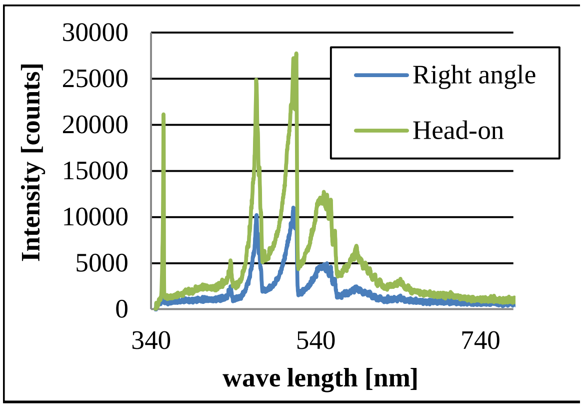

Fig.2. Spectroscopic measurement result of two arrangements; right angle and head-on collision.

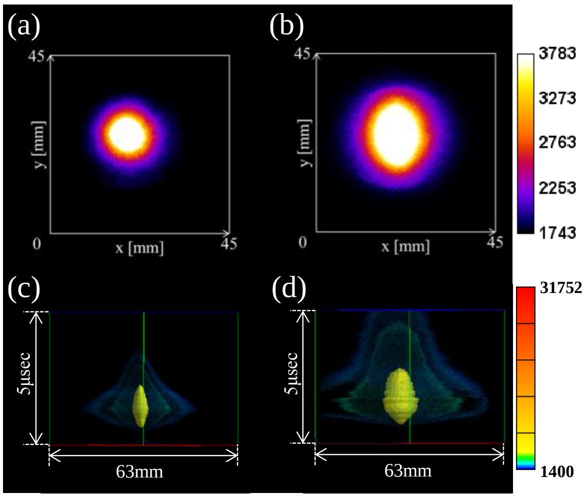

Fig.3. ICCD images 1.2 μsec after the beam irradiation, (a) Right angle collision (b) Head-on collision. Spatial integrated images, (c) Right angle collision (d) Head-on collision.

of the C2 Swan band. It is obvious that the Swan band intensity was stronger for the head-on than for the right angle collision.
In order to investigate time development of the plasma self-emission, ICCD imaging was performed. 100 frames were taken up to 5 μsec after the laser irradiation. Figure 3 shows plasma self-emissions taken at 1.2 μsec after the beam irradiation for (a) right angle and (b) head-on collisions. Taken areas were 45 mm by 45 mm squares. No optical filter was used. The exposure time window was 50 nsec. Volume rendering technique as a visual analysis was applied along the dotted line shown in Figure 1 [3] for (c) right angle and (d) head-on collisions. Comparing Figure (a) and (b), and (c) and (d), the differences of the emitting volumes were clearly indicated.

3. Discussion

From the results of Langmuir probe measurements, the two types of ablated plumes showed electron temperature and electron density each other very close.
From the spectral results at the ablation plume collision point, both types had the C2 Swan band. However C2 Swan band is larger for the head-on arrangement indicating that, C-C coupling has occurred efficiently.
From ICCD result Figure 3 (a) and (b), FWHM of plasma self-emission spatial distribution were 15.2mm at the right angle collision, and 25.5mm at the head-on collision. The self-emission of the head-on collided plasma was 1.6 times larger than the right angle. From ICCD result Figure 3 (c) and (d), time durations of self-emission with luminance value at 1800-1810, were 2.58 μsec at the right angle collision, and 3.99 μsec at the head-on collision. The self-emission of the head-on collided plasma was 1.5 times longer than the right angle with luminance value at 1800-1810.
From spectral and ICCD data, the main component of emission at the collisional point was C2 Swan band. The head-on arrangement created the emission in a larger volume and in a longer time. The C-C coupling occurred frequently, and more carbon aerosol seems generated.

4. Conclusion

In this experiment, we compared the difference of the ablation plasma collision as a model experiment of aerosol formation in the inertial fusion reactor. From Langmuir probe measurements, the parameters of the plasma ablated from two different target arrangements were seems similar. From spectroscopic and ICCD results, the head-on arrangement emitted C2 Swan band in a larger volume and a longer time. Thus more carbon aerosol seems generated at the head-on plasma collisional point.

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