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Accuracy improvement of ablated plasma measurement with Thomson scattering measurement method
トムソン散乱計測法を導入したアブレーションプラズマ計測の精度向上

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Two laser ablated carbon plasmas are crossed each other and formed a plasma column at the intersection in our laser experimental platform. At the intersection carbon product materials such as Onion fullerene, CNT and CMT etc. are created, but their forming conditions are not understood well. As a mean to obtain the conditions and to study the forming details, the intersection was irradiated at Nd:YAG laser (2ω, 8ns, 10Hz) as a basic step toward the Thomson scattering. Using a 30 nsec (time frame) 2D image camera, we could catch the scattering from these carbon materials clearly.

1. Introduction

In the study of plasma ablation assumed in IFE chamber wall, it is possible to promote detailed understanding the plasma by conducting a simulation experiment using pulse laser beams. In our experimental platform, the ablated plasma electron temperature and density are measured by Langmuir probes. This diagnostic method may encounter difficulty to measure the characteristics of high temperature and density plasmas in the case. Then as alternative plasma diagnostic method, we will employ Thomson scattering (TS) technique. This method is contactless with the plasma and high spatial resolution is porssible. We started the preparation for the TS measurement by irradiating the ablated carbon plasma (T_e ~6eV, N_e ~10^{19}/cm^3) with Nd:YAG laser (2ω, 8ns, 10Hz). Even at this preparation phase we observed very interesting features only possible from our experimental platform. The intersection of two laser ablated carbon plasma, where a plasma column is formed and carbon product materials including Onion fullerene, CNT and CMT are created [1]. This plasma column is irradiated at Nd:YAG laser (2ω, 8ns, 10Hz) and the scattered emission are measured. We have observed emission not directly from the plasma scattering, but very possibly from these CNT and CMT particles. Since their forming conditions are not understood well, this method can be a useful tool to understand the formation of materials such as Onion fullerene, CNT and CMT.

2. Experimental setup

Figure 1 shows a schematic diagram of the experimental setup. To measure scattered light from carbon product materials, a plasma column is formed using the experimental setup "LEAF-CAP" (**L**aboratory **E**xperiments on **A**erosol **F**ormation by **C**olliding **A**blation **P**lumes) [2]. Nd:YAG laser (3ω, 6ns, 10Hz) is optically split into equal-power. Each split beam is line-focused (~0.1mm by ~1cm, 10~11J/cm^2/pulse) to radiate two cone cave targets (Carbon) at room temperature in a vacuum chamber (~10^{-6}torr). The ablated plasma plumes are crossed each other at 12.8 mm away from the target surfaces and formed a plasma column (T_e ~1eV, N_e ~10^{12}/cm^3). Nd:YAG laser (2ω, 8ns, 10Hz, φ~8mm) can be injected at any desired timing and can lead to scattering if there are any scattering sources at the intersection. Scattered emissions are observed at a specific time with an intensified CCD (ICCD) camera. A 2ω band pass filter (524~532nm, 42~61%) has been used in front of the camera due to measure the scattered emission since the plasma emission coming from the intersection includes broad wavelength spectrum and the Carbon Swan band [3]. ICCD camera can measure 2D frame photo with 30 nsec time window with a variable time delay.

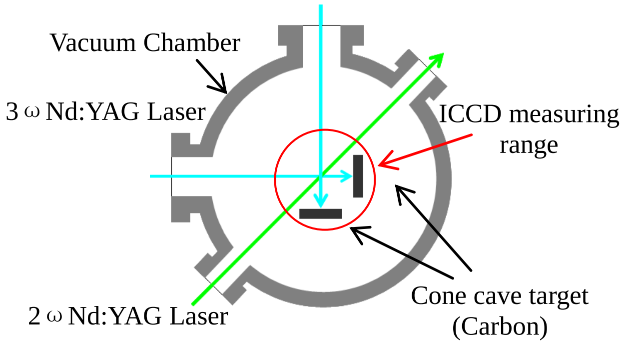

Figure 1 A schematic diagram of the experimental setup

3. Result and Discussion

Figure 2 shows an image how the laser ablated carbon plasmas cross each other, collide and stagnate. We know that there are many carbon product materials created through this process in the experiment. Figure 3 shows the result of ICCD observation (30 nsec time framed 2D image). The observation field of view corresponds to the red circles in Figure 1 and Figure 2 when plasma emission is the most strong in a sequence of ablated carbon plasma.

When 2ω Nd:YAG laser crossed plasma column, the scattered emission was measured around the plasma column repeatedly. The image was taken through the 2ω band path optical filter. The stray light was carefully removed from the measurement. As a result of comparing the result of Figure 3 with 2ω Nd:YAG laser only or 3ω Nd:YAG laser ablated plasma only, the emission in Figure 3 is the scattered emission from possibly the carbon product materials generated between inducing two ablated plasma plumes and crossing each other.

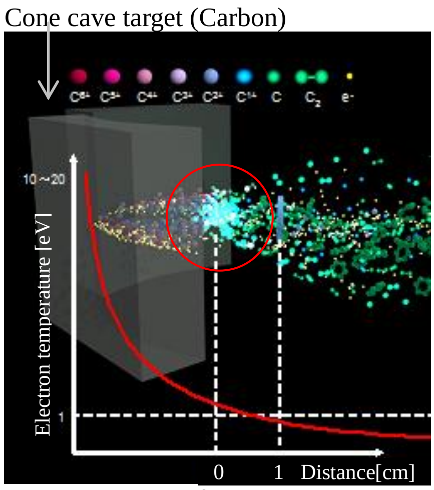

Figure 2 Ambience of laser ablated carbon plasma and carbon product materials

4. Summary

In the intersection where two carbon plasma plumes crossed each other, it is known to create carbon product materials. In the 30 nsec 2D imaged ICCD photo, we have captured clearly the scattered emission from possibly the carbon cluster formation. The formation may include CNT, CMT and Onion fullerene etc. The level of scattered light from both these product and plasma columns can be used to evaluate the laser intensity necessary for Thomson scattering measurement. We have shown that the 2ω probe laser can be used to study the amount and kinds of their materials using.

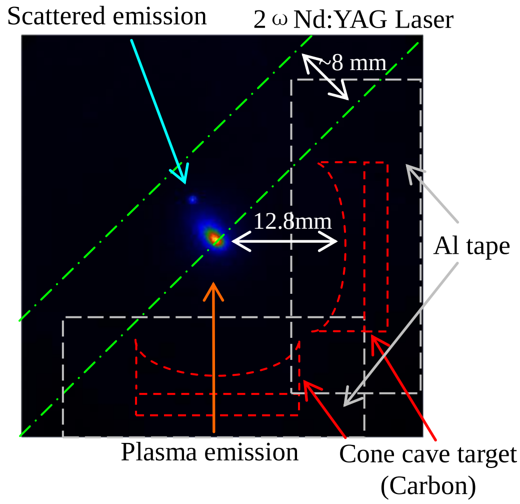

Figure 3 ICCD observation at the timing of max emission from the plasma column. The scattered emission indicates the scattering from carbon products.

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