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Ratio of Ions and Neutral Particles in Inertial Fusion Reactor Plasma Plume
慣性核融合炉におけるイオンと中性粒子の比からみたプラズマプルーム特性

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In inertial confinement fusion, the fusion reaction could lead the first wall ablation in reactors. It is important in reactor design to understand the behavior of the plasma plume by wall ablation. We simulate the ablation plasma of inertial fusion reactor by laser ablation experiments. Laser intensity is about 2-7×10^8[W/㎠]. And we use the carbon target that is one of the candidate materials of inertial fusion reactors. First, we measured the amount of ions and neutral particles contained in the carbon plasma plume. Next, we removed ions by the magnetic field and measured the amount of neutral particles only contained in the carbon plasma plume. From the result, we found out that ions and neutral particles are in the ratio of 1:4 at a distance of 6.5cm from the target surface when laser intensity is about 7×10^8[W/㎠].

1. INTRODUCTION

The first wall of inertial confinement fusion reactor (R ~ 5-10m) is subject to the pulse load (~1GW/ ㎠) and may be ablated by fusion reaction[1]. This ablation may form an aerosol in the reactor, and it will affect the following laser shot. In this study, we simulated the wall ablation of reactor by laser ablation[2, 3]. We used the carbon target: one of the candidate materials of inertial fusion reactors. The ratio of ions and neutral particles in the carbon ablation; will influence the behaviors of plume collision or stagnation. In order to differentiate the ions out of plasmas, we used the magnetic field.

2.EXPERIMENTAL SETUP

We irradiate a cone cave shaped carbon target with Nd:YAG laser (3ω, 1-4J/㎠, 6ns, 10Hz) to ablate it. The laser is line focused (1.0cm×0.1mm) on the target. The ablated plasmas focus at 1.4cm from the surface. The target is placed in the vacuum chamber (~ 0.01Pa).

Ablation plume is monitored as the deposition measured by a quartz thickness monitor[4] and a charge collector[5]. A quartz thickness monitor can measure ions and neutral particles in ablation plume. A charge collector can measure ions only. These measuring instruments are placed 5.0cm in front of focus and 2.0cm below axis of the laser.

Neodymium ring magnet produces the magnetic field to remove ions. The magnet is placed 2.0cm in front of measuring instruments.

3.EXPERIMENTAL RESULT

At first, it was confirmed by charge collector that ions in the ablation plume could be removed completely by the magnetic field. Fig.1 shows charge collector signal with a magnet and without a magnet when laser power density is 4 J/㎠. Time 0 is the moment the laser hit the carbon target. From Fig.1, the ratio of neutral particles and ions could be measured by a quartz thickness monitor and the magnet.

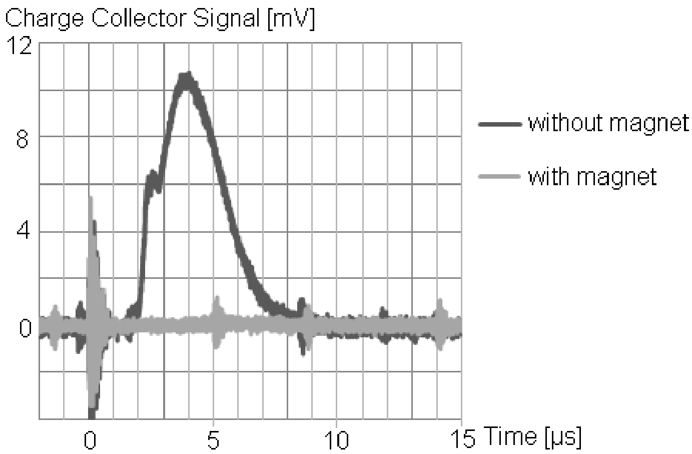

Fig.1) Charge Collector signal with and without magnet when laser power density is 4J/㎠

Next, Fig.2 shows the results of a quartz thickness monitor with and without the magnet. Because neutral particles are unaffected by the magnetic field, the decreased component is due to the ions in Fig.2.

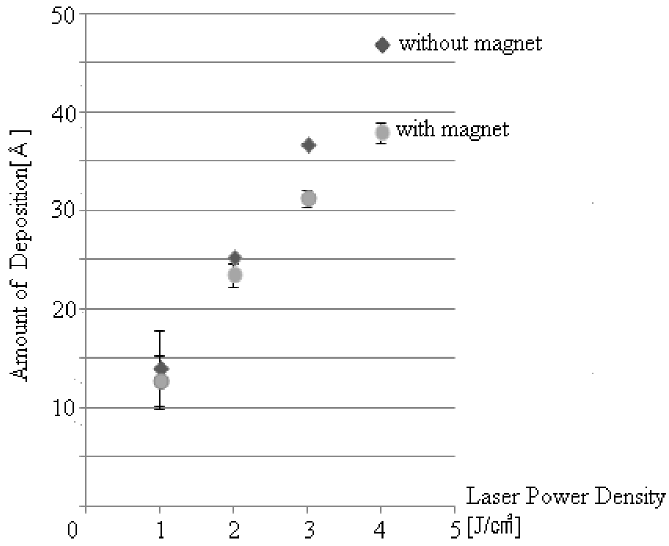

Fig.2) Result of Quartz Thickness Monitor with and without magnet

4.CONCLUSION

Fig.3 shows the ratio of ions in the carbon ablation plasma calculated from Fg.2. It is conceivable that the more laser power density increase, the more ratio of ions increase. But when laser power density is 2J/cm² or less, the tendency is not showed.

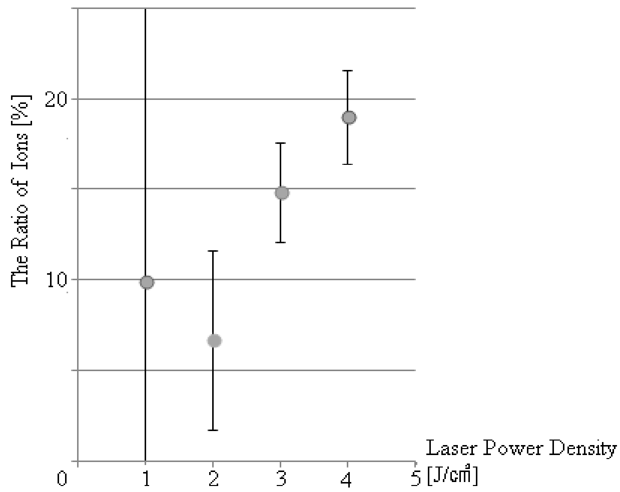

Fig.3) The ratio of ions in carbon ablation plasma where is 6.5cm in front of the target surface

5.PROBLEMS AND NEXT SUBJECTS

This experiment was performed by 4J/cm² or less. When we increased the laser power density, the charge collector signal with a magnet was not 0, that is to say, ions in the ablation plume could not be removed by the magnetic field of this magnet. And measuring instruments are placed 6.5cm in front of the target surface, so the plasma cooling effect is large. It is presumed that many ions become to be neutral.

We tried the same experiment for the tungsten target. Fig.4 shows the charge collector signal with a magnet was not 0 when the laser power density was 4J/cm² or less. Tungsten (~ 184g/mol) is heavier than carbon (~ 12g/mol). So tungsten is hard to be affected by the magnetic field[6].

In future, we will improve the experimental method and the accuracy of measuring.

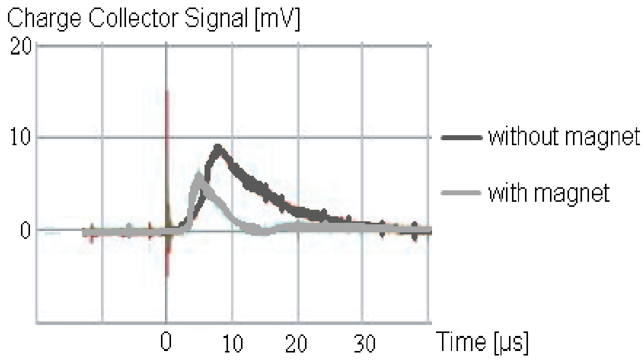

Fig.4) Charge Collector Signal with and without the magnet when laser power density is 4J/cm² Target material is tungsten

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