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Spatial distribution measurement of the detached plasma produced in the gas injection experiments of the GAMMA 10/PDX end-cell

GAMMA 10/PDXエンド部におけるガス入射実験時の
非接触プラズマの空間分布計測

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This paper describes the results on the spatial distribution of the line spectra in the central axis of the V-shaped target in divertor simulation module (D-module) together with the results of Langmuir probe at the corner of V-shaped target. As a result, the effects of radiation cooling and recombination with Xe gas injection were confirmed. In addition, the result about the shift of the region of ionization and radiation cooling was obtained by the measurement of the spatial distributions.

1. Introduction

Protection of plasma-facing components from the high-temperature plasma is one of the most important issues in order to control fusion plasma. Therefore, it is very effective to apply magnetic divertor which reduces the interaction of high heat-flux plasma to the plasma facing components. The reduction of the heat road to the divertor plates by promoting the radiation cooling is an urgent research subject to form the detached plasma.

One of the main objectives in the divertor simulation experiments is to produce detached plasma in D-module. In this study, the plasma cooling mechanism toward the detached plasma is investigated by injecting many kind of gases (Xe, Ar, Ne, N_2, etc...) [1]. In order to evaluate the radiation cooling due to impurity particles, a high-sensitive, high-resolution spectroscopic system has developed, and the gas injection experiment was performed with Xe gas. In this experiment, we measured the line intensity of Hα (656.27 nm), Xe I (480.70 nm) and Xe II (460.30 nm) emission using the spectrometer with multi-channel optical fiber while changing the plenum pressure of Xe gas.

2. GAMMA 10/PDX

In the GAMMA 10/PDX tandem mirror, high temperature plasmas are produced in the central-cell. Since the charged particles are transported to the end-cell in a high temperature state, we can conduct the experiment under the condition resembling the high performance plasma device. Furthermore, the open magnetic field configuration in the end-cell is suitable for the divertor simulation experiment.

3. D-module

In GAMMA 10/PDX, we have conducted the divertor simulation research using end-loss plasma flow with high heat-flux from the end-cell [2-6]. Last year, the divertor simulation experimental module (D-module) was installed in the west end-cell. In D-module, two target plates made of tungsten are mounted in V shape, as shown in Fig. 1.

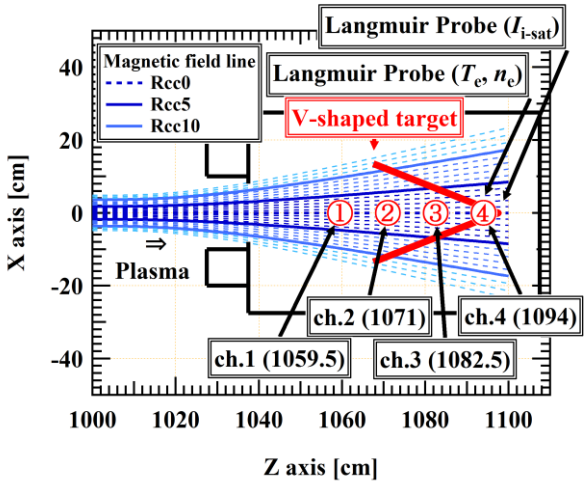

Fig.1. Interior view of D-module.

On the upper target plate, 13 electrostatic probes are installed and spatial distribution of the electron temperature and the density are measured on the target plate surface. On the lower target plate, 13 calorimeters are installed and the heat flux onto the target plate surface is measured. The angle of the V-shaped target can be changed between 15 and 80 degrees. In this study, we observed a V-shaped target from the side using the fast camera and the spectroscope with multi-channel optical fiber.

4. Experimental results and discussion

Fig. 2 shows the measured results, which are the electron temperature (T_e), the electron density (n_e) and Ion saturation current (I_{sat}), of Langmuir probe. I_{sat} decreases because it is found that n_e increases and T_e decreases, the effect of ionization seems to be dominant while the plenum pressure of Xe gas increases from 100 mbar to 400 mbar. In the case that the plenum pressure of Xe gas increases from 400 mbar to 1500 mbar, both n_e and T_e are decreased, which indicates that the effect of recombination is dominant.

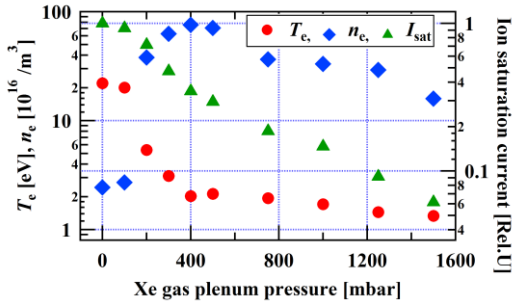

Fig.2. Measured results of Langmuir probe

In order to evaluate the effect of radiation or ionization, the spatial distributions of Hα (656.27 nm), Xe I (480.70 nm) and Xe II (460.30 nm) is measured using the fast camera and the spectrometer with multi-channel optical fiber.

Fig. 3 shows the intensity of those line spectra which is normalized the intensity during Xe 100 mbar injection. Even though the Xe II intensity at the corner of the V-shaped target (ch.4) was decreased in comparison with that of upstream of the plasma (ch.1), the Xe I intensity was increased in the case that the plenum pressure of Xe gas increases from 100 mbar to 400 mbar. In addition, the peak of Xe I intensity in the Xe gas dependence shifts to upstream of the plasma. From those results, according to the increase in the plenum pressure of Xe gas, it is suggested that the dominant reaction in the corner of V-shaped target (ch.4) changes from ionization phase to radiation cooling and then recombination and that such ionization and radiation areas shift toward the upstream.

Further discussion will be presented in the conference.

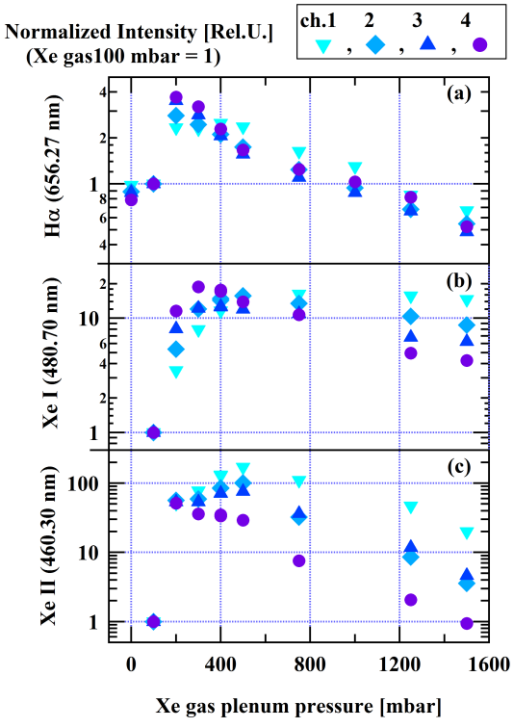

Fig.3. Normalized line intensity of Hα (a), Xe I (b) and Xe II (c). (The line intensity while Xe gas injected 100 mbar = 1)

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References

[1] Y. Hosoda et al.: Plasma and Fusion Research **9** (2014) 3402087.
[2] Y. Nakashima et al.: Fusion Eng. Des. **85** (2010) 956.
[3] T. Imai et al.: J. Plasma Fusion Res **87** (2011) 752.
[4] Y. Nakashima et al.: Trans. Fusion Sci. Technol. **59** (2011) No.1T, 61.
[5] H. Takeda et al.: Plasma and Fusion Research **7** (2012) 2405151.
[6] Y. Nakashima et al.: J. Nucl. Mater **438** (2013) 738.