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Influence of impurity transport and detached plasma formation in the experiments of gas injection to GAMMA10/PDX

GAMMA 10/PDXガス入射実験における非接触プラズマ形成と不純物輸送の影響

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In this paper, the detailed results on spectral measurement are reported and the argument on impurity transport is presented from the comparison of the spectral measurements in the end-cell and the plug/barrier-cell. Spectroscopic measurement in the plug/barrier-cell was carried out for the first time. Ionization behavior in the plug/barrier-cell showed different from that in the end-cell. Discussion of detached plasma generation from the change of electron temperature, density and emission spectrum by the gas injection conditions is also presented.

1. Intoduction

In order to study the detached plasma physics, we have conducted experiment with divertor simulation in tandem mirror device GAMMA 10/PDX [1-5]. In GAMMA 10/PDX, the divertor simulation experimental module (D-module) has been installed in the west end-cell. The main purpose of D-module is to realize the detached plasma. As diagnostic tools, two types of spectrometers are installed. By injecting gases, various experiments about divertor physics can be performed using D-module.

The purpose of this research is to analyze the mechanism of plasma cooling, impurity transport, and detached plasma formation. In the experiment, various types of gases have been injected in order to investigate the radiation cooling. Then, by using the spectrometers, the emission spectrum was measured. The detailed results on spectral measurement are reported. And the argument on impurity transport will be shown from the comparison of the spectral measurements in the end cell and the plug/barrier cell. Furthermore, characteristics of detached plasma were investigated by simultaneous injection of the Xenon gas and hydrogen.

2. Experimental Apparatus

Plasmas (T_i~4keV, T_e~100eV and n_e~$10^{18}m^{-3}$) are generated mainly in the central-cell by the ICRF wave and gas puffing. End-loss plasma from the central-cell flows to the end-cell. In D-module, two target plates made of tungsten are mounted in V-shape form. Langmuir probes which measure the electron temperature and density and calorimeters which measure the heat flux are installed on the target plate and at the corner of the V-shaped target. Three ports of gas injection system are installed in D-module.

As diagnostic tools, two types of spectrometers are installed show in Fig 1. One is a wide band-pass (190 nm ~ 889 nm) measurement using a small spectrometer (USB2000+). Another one is a high wavelength resolution (0.018 nm FWHM @372.26 nm) measurement using a high sensitivity spectrometer (SR500i). SR500i and USB2000+ are used in the end-cell. In the plug/barrier-cell, another USB2000+ is installed for the first time. In this study USB2000+ is measured at both end-cell and plug/barrier-cell. In SR500i, the wavelength resolution and band-pass can be adjusted with changing the diffraction grating. In this study, spectrum is measured with exposure time of 70ms, slit width of 10μm, and grating of 600 L/mm and 2400 L/mm in SR500i.

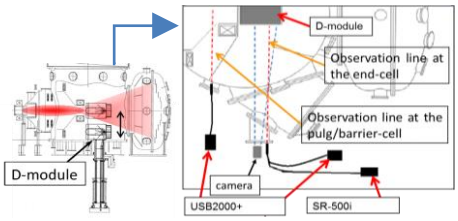

Fig. 1 Top view of west plug/barrier and end-cell

3. Experimental result and discussion

3.1 *Detached plasma formation with gas injection*

By the H_2 and Xe gas injection, detached plasma

is formed in D-module. H_2 and Xe gas are injected by the following parameters (H_2: 0.3 s before the plasma start, width 0.3 s, Xe : 0.4 s before the plasma start, width 0.4 s). Plenum pressure of Xe is varied from 0 to 1200 mbar. Plenum pressure of H_2 is fixed in 1000 mbar. Fig. 2 (a) shows the dependence of the intensities in the hydrogen Balmer series and ion saturation current. Plotted data are normalized by the intensity in the case of only H_2 gas 1000 mbar injection. The line intensity and the ion flux are reduced with increasing the amount of Xe gas injection. By injecting H_2 and Xe gas with plenum pressures of 1000 mbar and 500 mbar respectively, the ion flux was drastically decreased. This decrease of ion flux on the Xe plenum pressure indicated that plasma detachment occurred. The electron density has a n_e peak at the plenum pressure of Xe of 500 mbar. In the case that the plenum pressure of Xe gas was increased, the radiation of neutral particle decreased by 20~60 %, and the ion saturation current decreased by 80 %. It is suggested that the electron density reduced by recombination. It is estimated that Molecular Activated Recombination (MAR) is superior to Electron Ion Recombination (EIR) because of the temperature range of $T_e > 1$ eV.

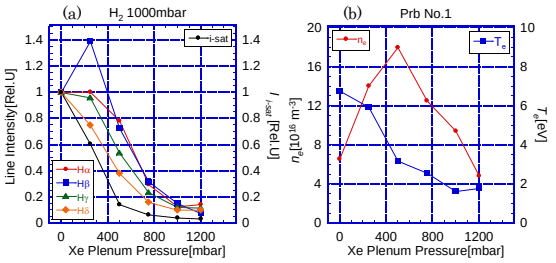

Fig.2 (a) The dependence on Xe plenum pressure of the intensities of the hydrogen Balmer series and ion saturation current. (b) the electron temperature and density at the probe number 1.

3.2 Observation of the impurity transport

Diamagnetism of the central-cell has been occasionally decreased by gas injection in D-module. It is considered that impurity back flow to the plug/barrier-cell is occurred, and then spectroscopic measurement was expanded to the plug/barrier-cell in the time.

In Fig.3, the intensity of the emission line spectrum in the end-cell was compared with that in the plug/barrier-cell. The emission of Xe I was observed in the end-cell. The emission of Xe I was not observed and Xe ions observed in the plug/barrier-cell. In the plug/barrier-cell, the emission intensity of Xe II increased and that of H_α decreased as Xe gas plenum pressure was increased. It is recognized from the figure that ionization process was in progress in the plug/barrier-cell. In the end-cell, on the other hand, the emission intensity of Xe I increased and that of Xe II and H_α decreased as Xe gas plenum pressure was increased. It is considered that the effect of the recombination process may have been appeared in the end-cell. In the case of Ar gas injection is shown similar dependence.

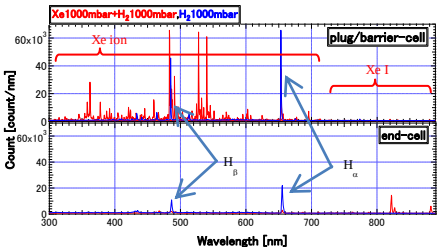

Fig. 3 The intensity of the emission line spectrum in the end-cell and the plug/barrier-cell

4. Summary

The Balmer series lines of hydrogen were observed by using the two spectrometers. Detached plasmas generated by gas injection were investigated on the basis of spectral measurement and in D-module. The Balmer series line intensity and the ion flux are reduced by increasing the amount of Xe gas injection, which implies the Spectroscopic measurement carried out in the plug/barrier-cell for the first time showed that Xe was almost ionized in the plug/barrier-cell. From the above observation, ionization process is in progress in the plug/barrier-cell, and the effect of the recombination process may have been appeared in the end-cell.

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