§3. Effect of Neutrals on Decrease in Heat and Particle Loads on the V-shaped Target in GAMMA10

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To realize a steady-state nuclear fusion reactor, one of the urgent issues is reduction of heat and particle loads onto the plasma facing components, especially the divertor targets. Divertor detachment is attractive to reduce heat and particle loads onto the divertor target. Although it is believed that neutrals play important roles to form detached plasmas, fundamental process such as interaction between plasmas and neutrals have not been fully understood yet. This study aims at elucidation of effects of neutrals on reductions of heat and particle loads using a V-shaped target in divertor simulation experimental module (D-module) in GAMMA 10/PDX. In the last fiscal year, an ASDEX-type first ionization gauge[1)] which can measure a neutral pressure in a strong magnetic field was installed in D-module to measure the neutral pressure during plasma irradiation to the V-shaped target. In this fiscal year, the gauge has absolutely been calibrated for H_2 gas and effects of H_2 gas pressure on electron temperatures and electron densities at the corner of the V-shaped target have been investigated.

Gauges can be absolutely calibrated by measurement of the ratio between the emission current (I_e) and the ion current (I_i), $I_i/(I_e\text{-}I_i)$, against absolute gas pressure, i.e. sensitivity. But absolute H_2 gas pressure cannot be measured in D-module because an absolute pressure gauge is not installed. Hence, to calibrate the gauge for H_2 gas, two experiments were performed in this study: one is measurement of the sensitivity for H_2 gas without a magnetic field, the other is measurement of sensitivity increase by the magnetic field of GAMMA 10/PDX in D-module. Absolute H_2 gas pressure in D-module was evaluated using the measured sensitivity by which increase by the magnetic field was corrected.

After the absolute calibration, changes of electron temperatures and electron densities at the corner of the V-shaped target by H_2 gas pressure during plasma irradiation were investigated. The plasma irradiation duration was 400 ms, and H_2 gas loaded in the reservoir (490 cm^3) with a pressure of 100 kPa was injected to D-module ~150 ms after the start of the plasma irradiation. The angle of the V-shaped target was set at 45°. Figure 1 shows temporal evolution of typical parameters. The diamagnetism and the electron line-density at the central were uniform at 10^{-5} Wb and ~5 × 10^{17} m^{-2}, respectively. Hydrogen gas pressure in D-module increased from ~200 ms and it reached to 10-20 Pa. It is hard to evaluate the H_2 gas pressure accurately because the reason why the H_2 gas pressure became negative values is not clear. But changes of the electron temperature and the electron density by H_2 gas pressure was observed clearly. The electron temperature at the inlet of D-module decreased from ~30 eV to ~15 eV. Larger decrease of the electron temperature was observed at the corner of the V-shaped target: the electron temperature decreased to ~5 eV. The electron density at the inlet increased from ~2 × 10^{16} m^{-3} to ~2 × 10^{17} m^{-3}. The electron density at the corner of the V-shaped target increased from ~2 × 10^{16} m^{-3} to ~6 × 10^{16} m^{-3} and it decreased to the initial value, which was one order of magnitude lower than that at the inlet of D-module.

The electron temperature and the electron density at the corner of the V-shaped target after the H_2 gas injection were lower than those at the inlet of D-module. These results suggest that particle loads onto the V-shaped target are decreased by interaction between incident plasmas and H_2 gas neutrals. In addition, rollover of the electron density which is observed at divertor targets in tokamaks was observed. This suggests that detached plasmas are formed in front of the corner of the V-shaped target.

In this study, decrease of the electron temperature and the electron density at the corner of the V-shaped target was observed with increase in H_2 gas pressure. The rollover of the electron density was also observed. These results would be due to interaction between incident plasmas and H_2 gas neutrals. To clear mechanisms of the reduction of the particle load onto the V-shaped target, interaction between incident plasmas and H_2 gas neutrals will be analyzed in detail.

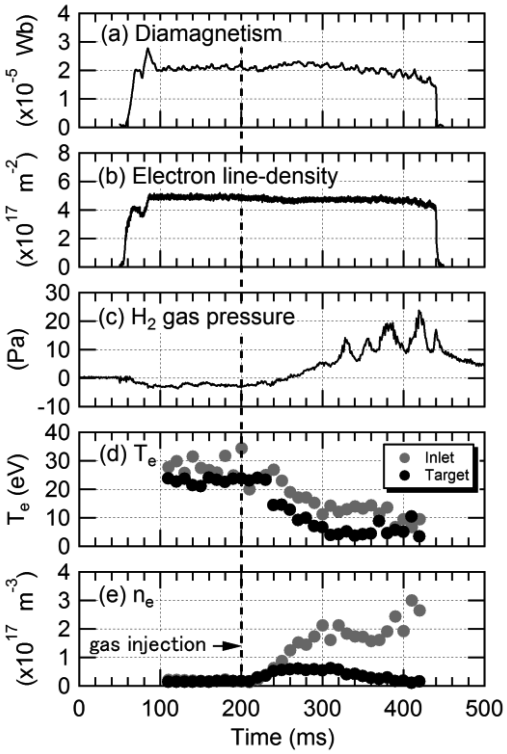

Fig. 1. Temporal evolution of typical parameters. (a) Diamagnetism and (b) electron line-density at the central of GAMMA 10/PDX. (c) Hydrogen gas pressure in D-module. (d) Electron temperature and (e) electron density at the corner of the V-shaped target.

1) Haas, G., et al.: J. Nucl. Mater. **121** (1984) 151.