§1. Study of Boundary Plasmas in Making Use of Potential and Heat-flux Control Effect of High Power Gyrotrons Coinciding with their Development and Open Magnetic Field Configuration

Ichimura, M., GAMMA 10/PDX Group (Univ. Tsukuba)

The GAMMA 10/PDX device has open magnetic field configuration and improvement of the plasma confinement with potential formations in both parallel and perpendicular directions to the magnetic field line has been demonstrated. By using the controllability of plasma parameters, divertor-simulation experiments at the end-cell region have been performed with strong ICRF and ECH systems. The ITER relevant level heat flux of 10 MW/m^2 at the end-cell has been obtained. Recently, the divertor simulation experimental module (D-module) has been installed on the west end of the device. This module has a V-shaped target plate and closed divertor structure. The target plate can be changed the angle and the pumping speed in the D-module is controllable. Two tungsten plates are mounted in V-shaped and these plates can be heated up to 300 degrees centigrade for studying interactions between plasma and wall materials under high temperature. Gasses are injected into D-module for realizing detached plasma operation and the clarification of radiation cooling mechanism toward the development of future divertor systems. In addition to the divertor simulation experiments, the development of high power gyrotrons is also main subject of the GAMMA 10/PDX device.

At the GAMMA 10/PDX end cell, high plasma temperature of T_i = 100 – 400 eV and T_e = 30 eV has been produced under the high magnetic field around 1 Tesla. In the experiment, target plasmas are produced and heated with ICRF waves in the central-cell. The maximum ion temperature becomes more than 10 keV in the perpendicular direction in the central-cell. Recently, additional ICRF antennas have been installed in the anchor and plug/barrier cells in order to increase both particle and heat fluxes at the west end. A remarkable increase of the end-loss flux up to 1.7×10^{23} m^{-2}sec^{-1} has been observed when ICRF waves are injected in both east and west anchor cells at the same time.

Figure 1 shows the dependence of the electron temperature (T_e) near the V-shaped corner measured with the probe, the heat flux (P_{heat}) and $I_{i\text{-}sat}$ measured with the corner detector in D-module on the plenum pressure of two kinds of injected gases (Xe, Ar). The measured T_e decreases with the increase of the gas throughput and is attained to a few eV at a plenum pressure of 1000 mbar in each case. P_{heat} also decreases with the plenum pressure and reduces to 20 - 30% of the case without gas injection at the same pressure. In the case of Xe injection, $I_{i\text{-}sat}$ is reduced to 20 % at the plenum pressure of 1000 mbar, however the reduction of $I_{i\text{-}sat}$ in the case of Ar remains small in spite of considerable reduction of T_e. This result indicates that Xe has stronger effect on the detached plasma formation than Ar. In the case of simultaneous injection of both Xe and H_2, ion flux is drastically reduced to less than 3 %, which shows the generation of strong detachment near the target corner.

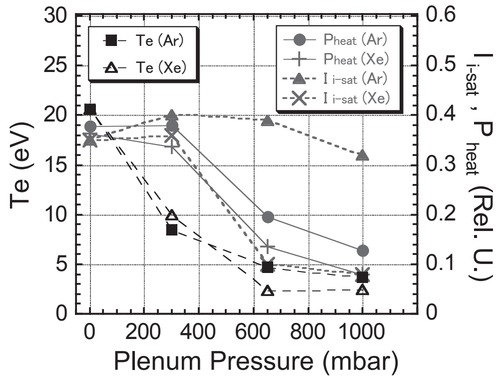

Fig.1 Dependence of the T_e and ion flux ($I_{i\text{-}sat}$) and heat flux on Ar and Xe plenum pressure measured with calorimeter and probe on the target plate and behind the V-shaped corner in D-module.

In University of Tsukuba, gyrotrons with wide range of frequencies from 14 to 300 GHz have been developed in collaboration with NIFS, JAEA and TETD. In joint program with NIFS, we have been pushing 77 GHz and 154 GHz and the total power of 5.14 MW is successfully injected into LHD by using three 77 GHz and two 154 GHz tubes which contributes to the improvement of the LHD plasma performance. A 28 GHz 1 MW gyrotron was adapted to QUEST of Kyushu University and the plasma heating effect was demonstrated. The design of dual-frequency gyrotron which can operate at 28 GHz and 35 GHz with more than 1 MW power has been completed for GAMMA10/PDX, QUEST of Kyushu University, NSTX of Princeton Plasma Physics Laboratory (PPPL) and Heliotron J of Kyoto University. A new gyrotron with 14 GHz is also under design for the application to QUEST and GAMMA 10/PDX. A 300 GHz gyrotron for DEMO has been developed in collaboration with JAEA and succeeded in 0.5 MW oscillation. Figure 2 shows the summary of MW gyrotron development in University of Tsukuba.

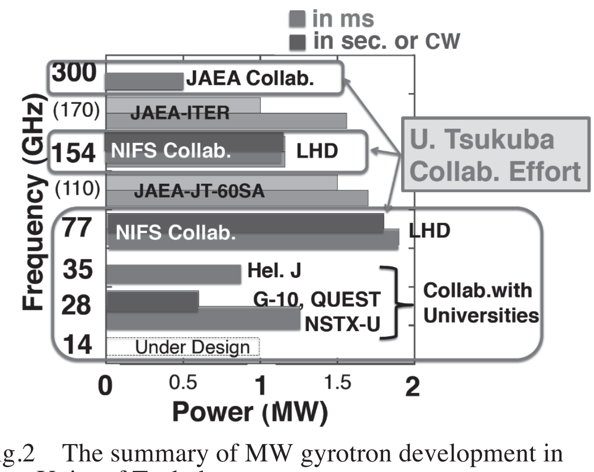

Fig.2 The summary of MW gyrotron development in Univ. of Tsukuba