§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

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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. Figure 1 shows the heat flux measured at the end-mirror exit plotted as a function of the ECH power in the plug/barrier cells. We achieved the highest heat flux of 15 MW/m^2 by superimposing a short pulse of ECH into the ICRF-heated plasma. 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 V-shaped target plate can be changed its 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. Several kinds of gasses are injected into D-module for realizing detached plasma operation and the characterization of physical mechanism of radiation cooling and recombination processes 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, the plasma flow with high 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 3.3×10^{23} m^{-2}sec^{-1} has been observed when ICRF waves are injected in both east and west anchor cells together with ECH in east plug/barrier cell.

In the divertor simulation research using D-module, 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 three kinds of injected gases (Ar, Ne and N_2). P_{heat} decreases with the increase in the D-module pressure and reduces to 20 - 30% of the case without gas injection. In the case of Ne, however, weak dependence on

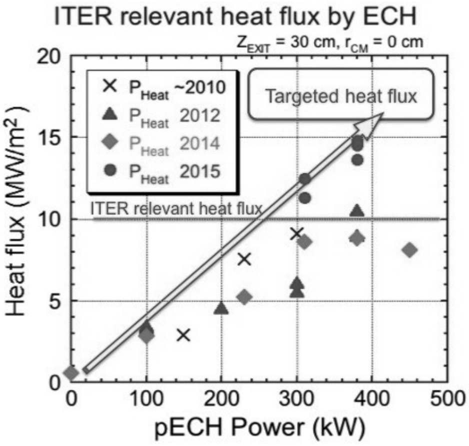

Fig.1 ECH power dependence on the heat flux.

P_{heat} is observed. This result indicates that Ne and Ar have stronger effect on heat and particle reduction than Ne. In the case of Xe injection, it is confirmed that Xe is the most effective on the detached plasma production and electron cooling than the other impurity gases. In the H_2 injection experiment into D-module, on the other hand, the decrease of plasma density along with the formation of detached plasma and significant is observed, which indicates the influence of molecular activated recombination (MAR).

In University of Tsukuba, gyrotrons with wide range of frequencies from 14 to 300 GHz have been developed in collaboration with JAEA, NIFS and TETD. In the development of the 28/35 GHz dual-frequency gyrotron tube, a steady progress has been achieved for GAMMA 10/PDX, QUEST of Kyushu University, NSTX of Princeton Plasma Physics Laboratory (PPPL) and Heliotron J of Kyoto University. The designing and fabrication have been completed and an oscillation test will be performed soon. A 28 GHz-1MW gyrotron tube for QUEST of Kyushu University has also succeeded in extending the highest power of 1.38 MW by increasing the beam current up to 55 Amps. A new gyrotron with 14 GHz is also under design for the application to QUEST and GAMMA 10/PDX.

Figure 2 shows the summary of gyrotron development in Univ. Tsukuba.

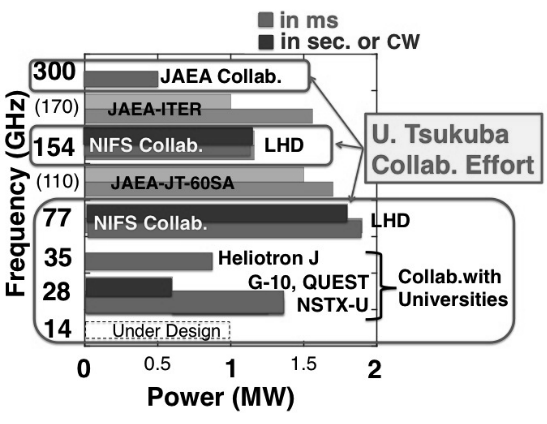

Fig.2 The summary of MW gyrotron development in Univ. of Tsukuba