§12. Experimental Study on Generation of High Heat Flux by ECH Modulation for ELM Simulation Experiments

Minami, R., Imai, T., Kariya, T., Numakura, T., Nakashima, Y., Sakamoto, M., Tsumura, K. (Univ. Tsukuba),
Kubo, S., Shimozuma, T., Yoshimura, Y., Igami, H., Takahashi, H.

Development of high power gyrotrons and electron cyclotron heating (ECH) systems for the power modulation experiments in GAMMA 10 have been started in order to generate and control the high heat flux and to make the ELM (edge localized mode) like intermittent heat load pattern for divertor simulation studies. ECH for potential formation at plug region (P-ECH) produces electron flow with high energy along the magnetic filed line. By modulating the ECH power, we can obtain arbitrary pulse heat load patterns. The heat flux factor increases almost linearly with ECH power. An intense axial electron flow with energy from hundreds of eV to a few keV generated by fundamental P-ECH is observed.

Figure 1 shows the P-ECH wave launching configuration and locations of the diagnostic systems used in the preliminary P-ECH modulation experiment to generate the high and ELM-like heat flux. In the vessel, a launcher composed of an open ended corrugated waveguide and two mirrors (MP1 and MP2) is installed. It radiated the microwave power to the resonance layer as shown in Fig. 1. The heat flux is measured by the movable calorimeter. This diagnostics instrument is located at 30 cm downstream from the end-mirror coil (z_{EXIT}=30 cm) and can be inserted from the bottom of the vacuum vessel up to the center axis of GAMMA 10. The flux and the energy spectrum of the end loss electrons are measured by a multi-grid energy analyzer (loss electron diagnostics, LED). End loss electrons enter the analyzer through a small hole on an electrically floating end plate that is located in front of the end wall.

The investigation of plasma flow from the end-mirror exit of GAMMA 10 is carried out to examine its performance relevant to the divertor simulation studies. The peak heat-flux of 11.4 MW/m^2 on the axis was obtained during the P-ECH injection. It continues to increase with ECH power. This value almost corresponds to the steady state heat load of the divertor plate of ITER. The energy density Q_{heat} per one pulse is plotted as function of the P-ECH power $P_{P\text{-}ECH}$ in Fig. 2(a). Typically, the radial profile of the heat flux density measured with the calorimeter had the peak on axis.

To achieve the generation of higher heat flux, it is necessary to design a high efficiency mirror antenna. Figure 2(b) and 2(c) show the calculated power density profiles on the resonance layer obtained in present mirror (MP2) system and new mirror (new-MP2) design. In new-MP2 design, it is achieved that the e-folding radius w of the power density of the radiation distribution on the resonance surface is ~40 mm and only MP2 surface is arranged without change of another mirror (MP1). The power density on the axis is inversely proportional to the square of w. Thus, if new mirror (MP2) is applied to ECH system, more two-time progress of the power density on the axis is expected.

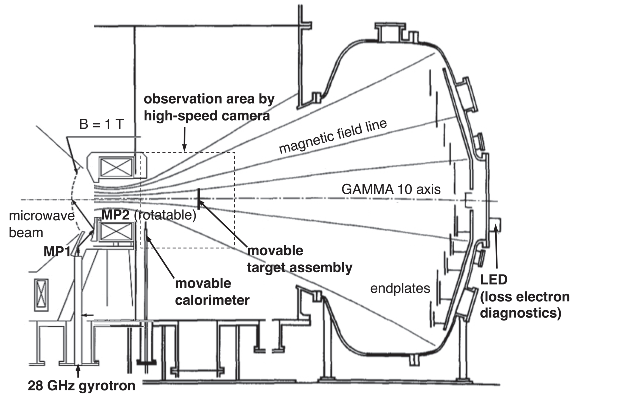

Fig. 1. Cross-section of the plug region and the end region. Microwave power is injected to the 1.0 T surface from the antenna. The LED is installed behind the innermost endplate.

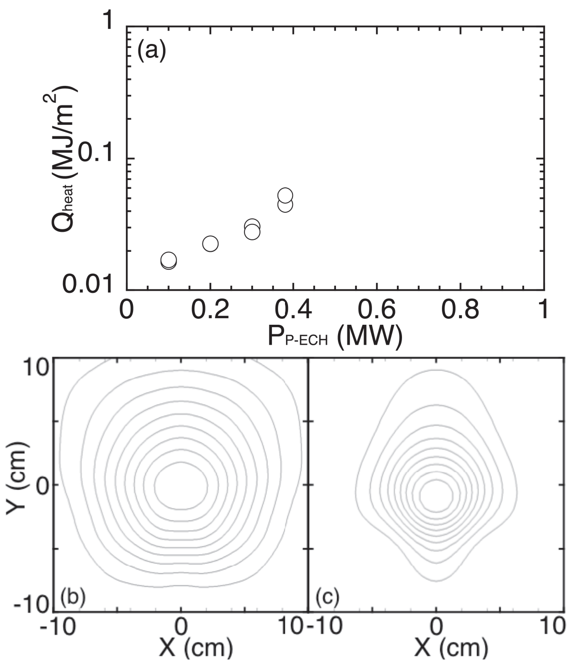

Fig. 2. (a) The P-ECH power $P_{P\text{-}ECH}$ dependence of the energy density Q_{heat} on the GAMMA 10 axis. Calculated power density profiles on the resonance surface in present mirror (b) and new mirror design (c).