24C08

Present Status of Divertor Simulation Experiments Using an End-cell of a Large Tandem Mirror Device

大型タンデムミラー装置端部を用いたダイバータ模擬実験計画の現状

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This paper describes the recent results of divertor simulation experiments using the GAMMA 10 tandem mirror device. In typical hot-ion-mode plasmas, measurements of heat and particle fluxes have been carried out by using the diagnostics installed at the end-mirror exit. The parallel ion temperature $T_{i//}$ obtained from the probe and calorific measurements increases with the RF power and agrees with the direct measurement of end-loss ion energy. The above results showed that the central-cell plasma could well control the performance of the plasma flow from the end-mirror exit. Near-term research plan for detailed PWI study and for further development of heat and particle fluxes is also described.

1. Introduction

In ITER discharges, heat load to the divertor materials is estimated to be 5~20 MW/m^2 in steady state and more at the transition phase [1]. To solve this problem, various so-called divertor simulators have been developed and a number of experimental approach have been made toward the realization of divertor.

In a large tandem mirror device GAMMA 10, plasma production/heating systems with the same scale of fusion devices have been equipped and high-temperature plasmas have been produced [2]. As a future research plan, making use of the advantage of open magnetic field configuration, we are planning to start a study of divertor simulation under the closely resemble to actual fusion plasma circumstances and to directly contribute the solution for realizing the divertor in ITER. For the above purpose, development of a new axi-symmetric divertor configuration and high heat-flux experiment in the end-mirror region are started [3-4]. In this paper, present status of the investigation on the characteristics of plasma flow from the end-mirror exit of GAMMA 10 performed to validate its applicability to the divertor simulation studies is reported.

2. Experimental Setup

Figure 1 shows the schematic view of the vacuum vessel of the west end-cell of GAMMA 10 and the plasma in the end-mirror region, together with the location of the diagnostic equipment. In order to proceed the research plan of the divertor simulation, several diagnostics have been prepared such as directional probes, calorimeters, and arrays of ion-energy analyzer as shown in Fig.1.

A high-speed camera and visible spectrometer also have been installed together with target disks consist of tungsten, carbon and stainless steel on a rotational mount at the down stream of the end-mirror exit in order to observe plasma material interactions on the target materials.

In GAMMA 10, a seed plasma is initially

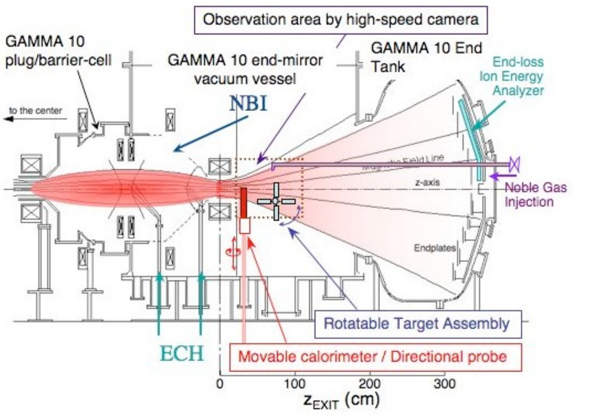

Fig. 1 Schematic view of the experimental setup.

injected from plasma gun at both ends and the plasma is build up with two ICRF waves (RF1 and RF2) together with gas puffing. Axially confining potential is produced by ECH at both plug/barrier-cells using high power gyrotrons.

3. Experimental Results

In typical hot-ion-mode plasmas (n_{e0} ~2×10^{18} m^{-3}, T_{i0} ~5 keV in the central-cell)[2], measurement of heat and particle fluxes from the end-mirror exit has been carried out. Heat flux is measured with the calorimeter and is determined from the temperature rise of the tip in a plasma discharge. Particle-flux density is determined from ion saturation current measured with directional probe.

Figure 2 shows ICRF power dependence on the parallel component of ion temperature, $T_{i//}$ in the end-loss plasma flux measured with the directional probe and the calorimeter. $T_{i//}$ directly measured by using end-loss ion energy analyzer (ELIEA) installed in the end-cell, which is located 300 cm away from the end-mirror exit, is also plotted in Fig.2. Both data agree with each other and is in proportion to the ICRF power.

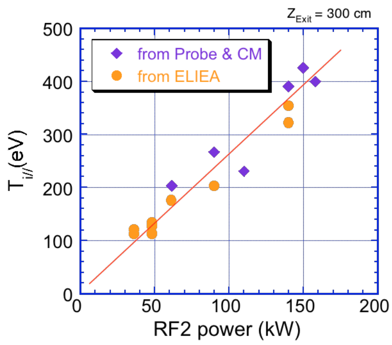

Fig. 2 ICRF power dependence on parallel ion temperature.

In Fig. 3, the ion-current density measured with ELIEA (I_{sat}) is plotted as a function with the line-density of plasma electrons measured at the central-cell (NLcc). A good linearly is observed and

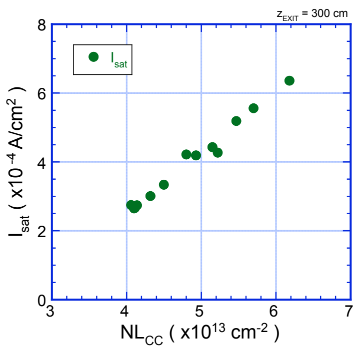

Fig. 3 Density dependence on ion-current density measured at the end-cell.

it is clearly found that the central-cell plasma parameters can well control the parameters of end-loss ion flux.

4. Near-term Research Plan

Based on the above shown results, the following research plan has been considered in near future:

(1) Installation of the divertor experimental-cell (D-cell) with V-shaped target in the end vacuum chamber and generation of strong plasma-surface interactions and realization of plasma detachment using gas injection,

(2) Installation of test material pieces in front of the D-cell and high the heat flux plasma irradiation and surface analyses,

(3) Divertor pumping experiment using the large capacity helium cryopumping system,

(4) Building-up the heat flux by adding a new RF system to the end-mirror cell.

The schematic drawing of the future research plan is shown in Fig.5.

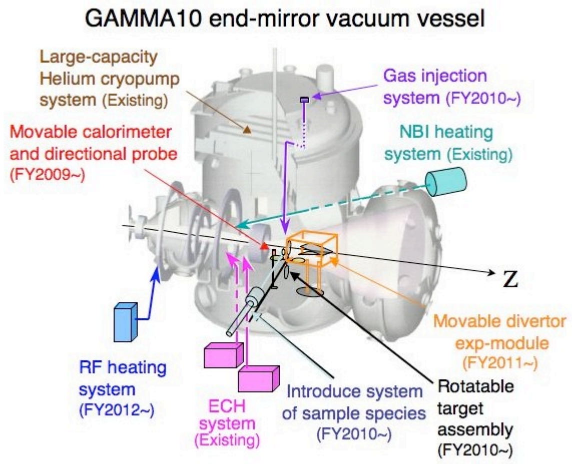

Fig. 4 Schematic drawing of the future research plan in the GAMMA 10 end-cell.

5. Summary

In the GAMMA 10 west end-cell, high-power plasma-flux generation experiments have been performed. Measured results of heat and particle fluxes showed that the central-cell plasma could effectively control the performance of the plasma flow from the end-mirror exit.

References

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