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Development of Divertor Simulation Research in the GAMMA 10/PDX Tandem Mirror

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This paper presents the first achievement of detachment from high temperature plasma equivalent to the SOL plasma of tokamaks using a large tandem mirror device. In Plasma Research Center, University of Tsukuba, we have started divertor simulation experiments at the end-cell of GAMMA 10/PDX (E-divertor) in order to realize the divertor simulation closely resemble to actual divertor environment [1, 2].
The first experiment for realizing detached plasma state from the high-temperature plasmas has been performed using H_2 and noble gas injection in the divertor simulation experimental module (D-module) recently installed in the west end-cell of GAMMA 10/PDX. Here, the plasma with n_e ~2×10^18 m^-3 and T_i// ~150 eV was produced with two ICRF waves (RF1 and RF2) in the upstream region (central-cell). The highest electron density of 2.4×10^18 m^-3 was obtained by simultaneous injection of H_2 and Xe into D-module. The particle and heat fluxes on the V-shaped target plate mounted in D-module were measured and the dependence on the Ar plenum pressure was examined. As increasing the amount of injection gas, both particle and heat fluxes continuously decrease. It is also observed that the electron temperature is drastically reduced from few tens eV to ~3 eV due to the Ar injection. Furthermore, in the case with H_2 and Xe, the ion flux was almost fully suppressed at the V-shaped corner. At the same time, 2-D image of Hα emission captured with the fast camera showed the clear detachment of emission zone from the target plate. Above results clearly show the evidence of plasma detachment in D-module.
Recently two antennas for additional ICRF heating (RF3) were installed in anchor cells in order to build up both particle and heat fluxes at the end-cell. A remarkable increase of the plasma density and end-loss ion flux is achieved during RF3. We evaluated the particle flux at the mirror exit by investigating correlation between particle flux determined from the probe measurements near the mirror throat and the end-loss ion current measured with end-loss ion energy analyzer (ELIEA). From this evaluation, the particle flux is estimated to be 1.7×10^23/m^2 s at the end-mirror exit.

[1] Y. Nakashima, et al., Fusion Eng. Design volume 85 issue 6 (2010) 956-962.
[2] Y. Nakashima, et al., Journal of Nuclear Materials 438 (2013) S738-S741.

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