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Recent Progress of Divertor Simulation Research Using the GAMMA 10/PDX Tandem Mirror

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This paper describes the characteristics of detached plasma produced by using hydrogen and noble gases together with the progress of high-heat and particle flux generation experiments in the GAMMA 10/PDX end-cell. In Plasma Research Center, University of Tsukuba, divertor simulation experiments have been started at the end-cell of GAMMA 10/PDX (E-divertor) [1]. In the GAMMA 10/PDX end-cell, plasma flow with high temperature (Ti = 100 ˜ 400 eV, Te = 30 eV), heat and particle fluxes (> 10 MW/mˆ2, >10ˆ23/mˆ2 s, respectively) have been produced under the high magnetic field (˜1 Tesla), which cannot be attained by conventional liner devices [2]. We have succeeded in achieving detachment of high temperature plasma equivalent to the SOL plasma of tokamaks in spite of using a linear device with short connection length of magnetic field line. Various gases (N2, Ne, Ar, Xe) are examined to evaluate the effect of radiation cooling against the plasma flow of MW/mˆ2 level in a divertor simulation region and the following results are obtained: (i) Xe gas was most effective on electron cooling (down to ˜2 eV) and reduction of heat and particle fluxes (1%, 3%, respectively). (ii) Ne gas was less effective. On the other hand, (iii) N2 gas showed more favorable effects than Ar. The above results are almost consistent with the observation from an absolutely calibrated visible spectrometer viewing the inside of D-module, such as (i) stronger emission from Xe I and II, (ii) significant molecular visible-emission from N2, etc. Furthermore, in the case with a simultaneous injection of Hydrogen and Xe gases, the ion flux was almost fully suppressed, which indicates the existence of Molecular Activated Recombination in D-module.
In plasma flow generation experiments, ICRF heating in anchor-cell successfully extended the particle flux up to 3.3 x 10ˆ23/mˆ2 s in the end-cell. Superimposing the ECH pulse (380 kW x 5 ms) into the ICRF plasma also succeeded in extending the highest heat flux of ˜15 MW/mˆ2 which exceeds the ITER divertor heat load in the steady state. These results will contribute to the progress in detached plasma operation and clarification of radiation cooling mechanism towards the development of the future divertor.
[1] Y. Nakashima, et al., Fusion Eng. Design volume 85 issue 6 (2010) 956-962.
[2] Y. Nakashima, et al., Journal of Nuclear Materials 463 (2015) 537-540.

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