§7. High Efficiency Gas Divertor Control by Molecular Associated Recombination Process

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The control of the detached plasma is thought to be a key issue in order to reduce the heat flux at divertor plates. In a detached plasma, the recombination process associated with molecular reactions, such as the molecular activated recombination (MAR) involving a vibrationally excited hydrogen molecule, has been emphasized in theoretical investigation and modeling. Especially, the negative ion plays an important role in the mutual neutralization of MAR, providing a new method of controlling detached plasma. [1,2]

In this paper, we have developed a new way to control detached plasma based on the utilizing H^- ions formed in the course of the mutual neutralization of MAR in the circumference of the plasma on the linear divertor plasma simulator, TPDSHEET–IV (Test Plasma produced by Directed current for SHEET plasma).

The TPDSHEET–IV was divided into two regions: the sheet plasma source region and the experimental region. Hydrogen sheet plasma was produced by the modified TP-D type dc discharge. The anode slit was 2 mm thick and 40 mm wide. The strength of the uniform magnetic field in the experimental region formed by ten rectangular magnetic coils was of 0.7 kG. The sheet plasma was terminated by the electrically floated and water-cooled target plate, which was made of stainless steel at the axial position of z = 0.7 m from the discharge anode electrode. The hydrogen plasma were generated with the hydrogen gas flow of 70 sccm at the discharge current of 50A. The neutral pressure P_{Div} in the experimental region was able to be controlled from 0.1 to 20. mtorr by feeding a secondary gas. The electron temperature and the electron density were measured by the Langmuir probe. The heat load, Q, was measured with the calorimetric method. A cylindrical probe made of tungsten (0.4 x 2 cm) was used to measure the spatial profiles of H^- by a probe-assisted laser photodetachment method. The concept of control of detached plasma by negative ion can be shown as following steps; (1) to measure the experimental data related to the basic parameters (gas pressure P_{Div}, heat load Q) in order to determine a threshold values of upper limit, (2) to control a secondary gas-flow rate G_{Div} so quickly as to keep the maximum value of the negative on density n_{H^-}, (3) to carry out a real time feedback control in order to maintain the steadily detached plasma in the neighborhood of the target plate.

Figure 1 shows the sequential profiles of G_{Div}, P_{Div}, n_{H^-}, Q, and discharge current I_d under the feedback control of the divertor plasma. At the time of 480 and 800 s, the value of I_d changes from 50 to 70 A. Both Q and P_{Div} is depressed by the feedback control of the detached plasma based on the negative ions formation in the circumference of this plasma. The value of Q and P_{Div} keep the lower value around 0.1-0.2 MW/m^2 and 3-4 mtorr with increasing I_d, respectively. It is found from the experiment that the detached plasma is maintained steadily in the neighborhood of the target plate under the feedback control by the secondary gas-flow rate so as to keep of the maximum value of the negative ion density and the constant neutral pressure. Also, it is found that this system well adapts to the rapid change of the discharge current. The new system has achieved the goal to reduce both heat flux and gas flow rate in the detached plasma.

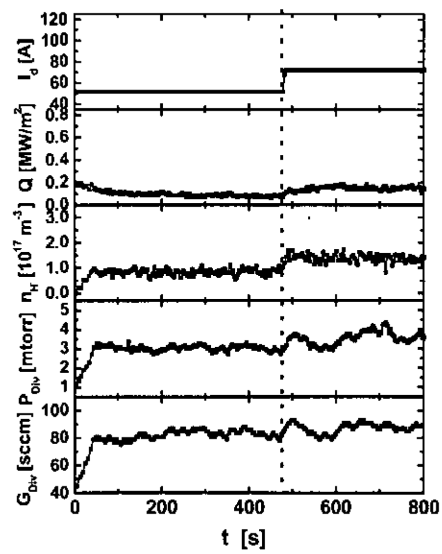

Fig.1. The sequential profiles of the secondary gas-flow rate G_{Div}, the neutral gas pressure P_{Div}, the negative ion density n_{H^-}, the heat load to the target Q, and discharge current I_d under the feed back control of the divertor plasma.

Refernce
1) Tonegawa, A. et al: J. Nuclear Materials, 313-316, (2002) 1046.
2) Ogawa H., et al: to be accepted in J J. Plasma Fusion Res. Vol.6(2004).