§8. Experimental Study of Compatibility of a Transport Barrier and Energetic Ion Confinement

Sasao, M., Kitajima, S., Shinto, K., Takahashi, H., Tanaka, Y., Utoh, H., Nishimura, H., Kubo, N. (Tohoku Univ.)
Ogawa, H. (JAERI)
Takayama, M. (Akita Pref. Univ.)
Nishimura, K., Nagayama, Y., Isobe, M., Nishiura, M., Inagaki, S., Yokoyama, M.

The confinement of energetic ions is one of key issues for the prospect to a steady state reactor plasma using a helical system[1]. Complex motions of trapped particles in helical systems tend to enhance the radial transport. It has been known that a radial electric field might effect on the confinement of trapped particles, while it play an important role to form transport barriers and to realize improved modes. In this Joint Research, we study the compatibility of a transport barrier and energetic ion confinement in helical systems.

In the Tohoku University Heliac (TU-Heliac), the influence of a radial electric field on the improved modes has been investigated by electrode-biasing experiments. In both positive and negative biasing experiments with a stainless steel (SUS) electrode (cold-electron or ion collection), the improvement of plasma confinement was clearly observed when the radial electric field was formed [6]. Furthermore, by negative biasing with a hot cathode (electron-emission), the radial electric fields can be actively controlled as a consequence of control of the electrode current, I_E

In this academic year, two diagnostic systems, a 1m high a new Titanium (Ti) electrode was fabricated, installed on TU-Heliac, and first experimental results were obtained. Using an electrode made of a hydrogen storage metal, such as Titanium (Ti) or Vanadium (V), the following can be expected: (1) ions accelerated from the positive-biased electrode allow simulation of the orbit loss of high-energy particles, and (2) the electrons or neutral particles injected from the negative-biased electrode provide production of high density plasma if hydrogen is successfully stored in the electrode.

Positively biased experiments were carried out after treatment for hydrogen storage ($p_{H2} = 2.7\times10^5$ Pa, 12 hours). The biasing resulted in increases in the plasma potential, and the line intensity of H_α and the electron density increased by about 2-fold as compared with those before biasing. Figure 1 shows the differences in the profiles of (a, e) the electron density, n_e, (b, f) the electron temperature, T_e, (c, g) the plasma potential, V_s, and (d, h) the radial electric field, E_r, measured with the triple probe, between the SUS electrode (left side) and the Ti electrode (right side) biasing experiments, both before biasing (solid circles) and during biasing (open triangles). In the case of Ti electrode biasing, the radial distribution of the electron density sloped steeply at $r = 60 \sim 90$ mm (e) and a strong positive radial electric field was formed at $r = 100 \sim 120$ mm (h), indicating improvement of plasma confinement. In positive biasing, an electrode is collecting electrons. In biasing of both the SUS electrode and the Ti electrode, the electrode currents were almost the same. This current level was too high to induce the improved mode for SUS electrode biasing. On the other hand, in the plasma biased by the Ti electrode, the electron density increased inside the electrode position. This suggested that the hydrogen storage electrode made of Titanium injected hydrogen ions.

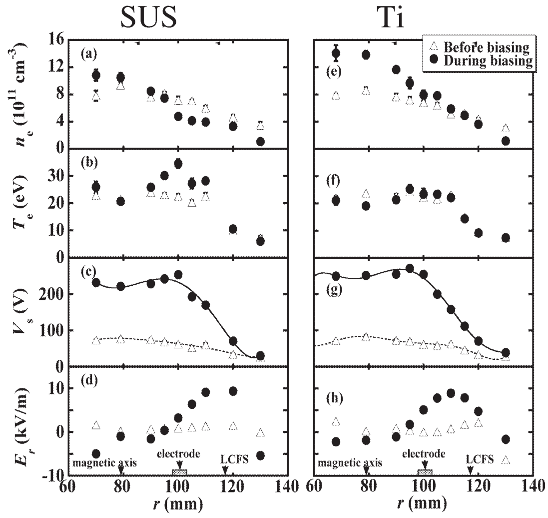

Fig. 1 Comparison of the SUS electrode (left side) biasing experiment with the Ti electrode (right side) biasing experiment profiles of (a) the electron density, n_e, (b) the electron temperature, T_e, (c) the plasma potential, V_s, and (d) the radial

In order to study the energetic particle confinement in an Heliac configuration, the classification of orbits were investigated using a full-gyro-orbit calculation. In fig. 2 is shown the confinement region of a proton of 75 eV in a ρ−χ plane. If the electrode biased at 75V emits protons in TU-Heliac, particles of initial pitch angles over 60 degrees might be promptly loss.

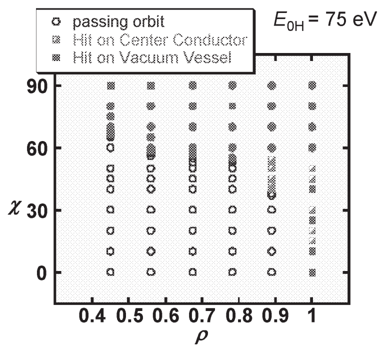

Fig. 2 The energetic particle loss region of TU-Heliac in a ρ−χ plane.

References
[1] Sasao, M. et al., Proceedings of 18 IAEA Fusion Energy Conference, IAEA-CN-77/EX9/1(Sorento, October 2000).
[2] Kitajima, S. *et al.* Proceedings of 20 IAEA Fusion Energy Conference, IAEA-CN-116/EX/9-3(October 2004).
[3] Utoh, H. *et al.* Proceedings of EPS2005 (P2.006).