§22. Broad-scale Edge Plasma Diagnostics with Several Types of the Langmuir Probes

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Detailed understanding and improving prediction of steady and non-steady state edge plasma characteristics are essential issues for success of ITER and DEMO reactor. In the divertor region, huge peak heat flux flowing into the divertor plate must be reduced to an appropriate level; thus, cross-field transport appearing around the divertor region is thought to be a desired phenomenon. On the other hand, in front of the first wall, such cross-field transport makes the plasma density high at this region, wreaking a damage on the surface of the wall. For measurements of edge plasma parameters and such a cross-field transport, Langmuir probe is one of the effectual diagnostic approaches.

In order to investigate the broad-scale edge plasma behaviors, we have operated several types of the Langmuir probes in the Large Helical Device.

(i) Toroidal divertor probe arrays
(ii) Poloidal divertor probe arrays
(iii) First wall probes
(iv) A fast scanning probe with three probe tips
(v) A fast scanning probe with an ion sensitive probe

Toroidal and poloidal asymmetries of the divertor plasma were detected by (i) and (ii), respectively. The far-SOL was investigated with (iii); the ergodic region and the divertor leg was measured by (iv) and (v).

In the 18th experimental campaign, we replaced the 2-I divertor probe arrays (2L and 2R) of (i) by a newly designed type, as shown in Fig. 1. Probe tips formed three rows and been aligned along the strike point. By using three probe tips, we have applied the triple probe measurement, which has an advantage of time resolution compared with the conventional single probe measurement. This can simultaneously estimate the several parameters, such as the ion saturation current (I_{sat}), the electron density (n_e), the electron temperature (T_e), the floating potential (V_f), and so on.

Figure 2 shows an example of the time series of these plasma parameters measured in a detached divertor plasma discharge (t > ~3.6 s) with the resonant magnetic perturbation field for R_{ax} = 3.9 m. During the detached state, large intermittent spikes appeared at a frequency of several dozen to ~100 Hz. By using the triple probe method, it was firstly found that these intermittent spikes have higher n_e and T_e than the background detached plasma.

This triple probes also informed us the divertor plasma parameters during steady-state plasma discharges in quasi-real time, because this method does not require a time-consuming procedure unlike the single probe measurement. Before a portion of discharge terminations, an increase of n_e in the divertor plasma due to difficulty of the density control was clearly confirmed.

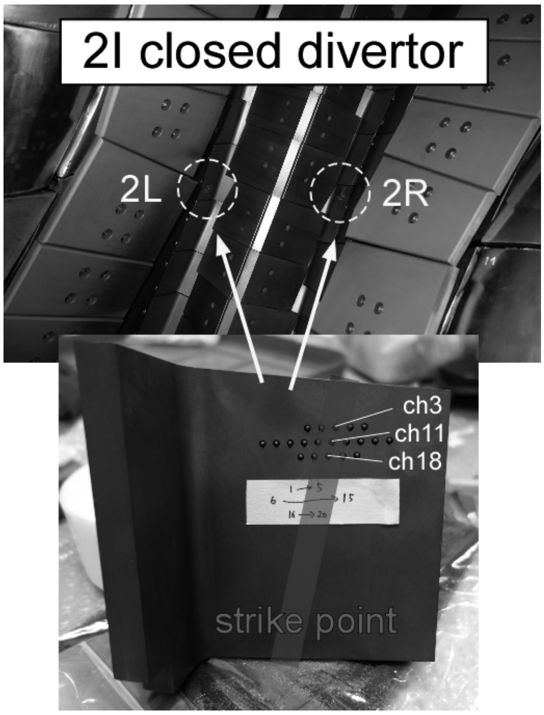

Fig. 1 Photographs of the 2-I closed helical divertor and the divertor probes. Position of the strike-point for R_{ax} = 3.9 m was roughly depicted.

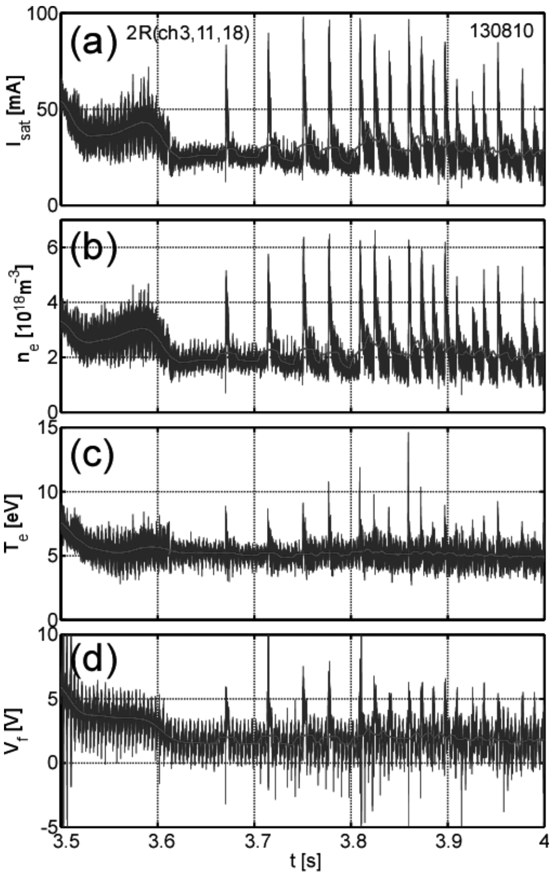

Fig. 2. Time series of (a) I_{sat}, (b) n_e, (c) T_e, and (d) V_f on the 2R divertor plate estimated with the triple probe method.