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Hybrid Probe Measurement of Peripheral Plasma on CHS

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1. Introduction

Recently, an edge transport barrier (ETB) formation with clear transition of H_α intensity has been observed in an NBI heated plasma on CHS [1], and understanding the mechanism underlying such phenomena is important and key issue for nuclear fusion research from the viewpoint of confinement improvement. The increase of plasma density in the edge region after the drop of H_α intensity has been observed by Thomson scattering, beam emission spectroscopy (BES), and Lithium beam probe measurements. In order to investigate in detail peripheral plasma near the last closed flux surface (LCFS), a multi-channel probe has been installed with a two-dimensional probe drive in outer edge region of horizontally elongated cross-section in CHS. Each probe head on the probe surface has a sheath thermocouple and acts as a calorimeter. Thus the probe can be used as not only conventional multi-channel Langmuir probe but also heat flux probe, so is called "hybrid probe". In this paper, the construction of the hybrid probe and two-dimensional probe drive are presented in section 2, experimental results of the probe measurement in section 3, and summary in section 4.

2. Hybrid Probe

Hybrid probe has been designed to measure both local plasma parameters by conventional Langmuir probe method and local heat flux. The probe is made of oxygen free high conductivity copper (40mm in diameter) with a water cooling system. There are ten probe heads (4mm in diameter) on the probe surface, and each head has a sheath thermocouple in order to estimate the local heat flux in a peripheral plasma (see fig. 1(a)). The probe is electrically isolated by CHS vacuum chamber, so keeps floating potential in plasmas. The voltage of each probe head is same and is able to be swept by a power supply.

Another feature of this measurement is to obtain the spatial distribution of some plasma parameters using a two-dimensional probe drive. The probe is inserted by a linear drive (750mm travel), of which insertion angle can be changed from -4 degrees to 20 degrees in the major radius direction. Thus a probe is able to scan in R-z space in wide region of horizontally elongated cross-section (see Fig. 1(b)). However, the insertion angle of the hybrid probe is

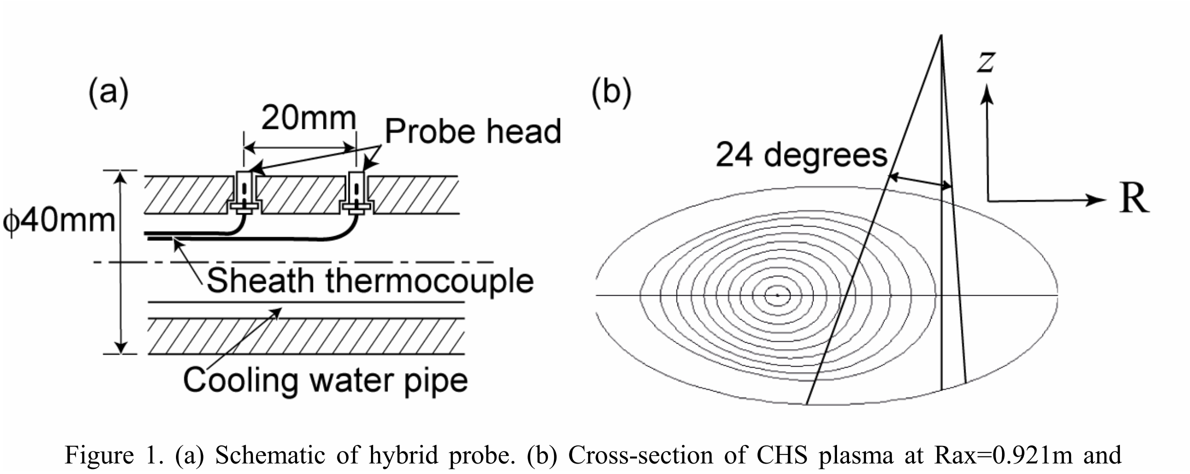

Figure 1. (a) Schematic of hybrid probe. (b) Cross-section of CHS plasma at Rax=0.921m and scannable area by the two-dimensional probe drive.

limited from -4 degrees to 4 degrees because of the size of the probe. A narrow probe less than 10mm in diameter is able to scan without the dimensional limitation.

3. Experimental Results

3-1 ETB formation The investigation of peripheral plasma with ETB using the hybrid probe has been performed in CHS. The ion saturation currents of ETB plasma were measured and the increase of ion current at R=1172mm (about 10mm inside of LCFS) with the reduction of H_α intensity was observed, while no clear change was observed at R=1207mm (about 25mm outside of LCFS), which are shown in Fig. 2 (a). The profiles of ion current were measured on z=0 line in the horizontally elongated cross-section. In Fig.2 (b), the four radial profiles of ion saturation currents in CHS plasmas (S.N.:114200-114211) are shown; case A (65msec): without ETB before the H_α reduction, case B (~72msec): onset of H_α reduction, case C (~77msec): the end of H_α reduction, and case D (85msec): with well-developed ETB. The electron temperature was also measured by sweeping the probe bias and was 8-20 eV in

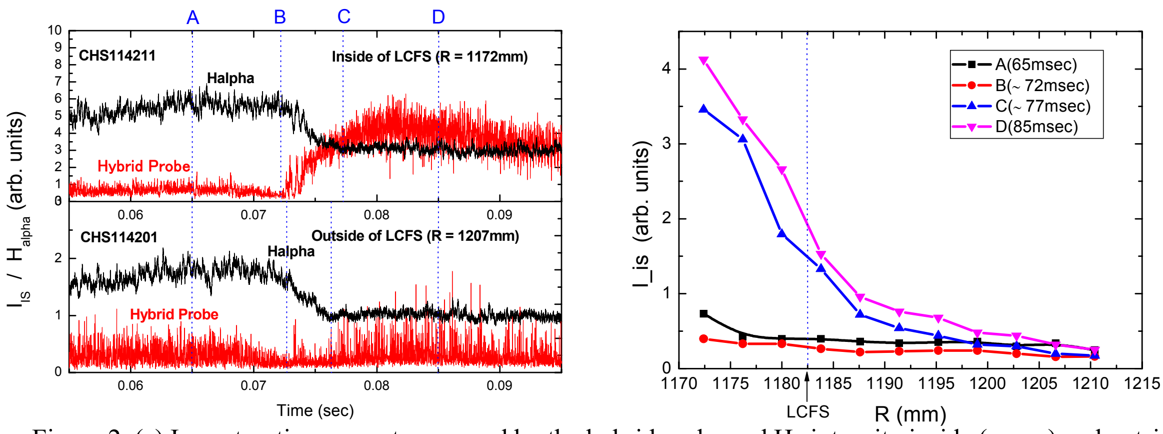

Figure 2. (a) Ion saturation current measured by the hybrid probe and H_α intensity inside (upper) and outside (lower) of LCFS. (b) Ion current profiles measured by the hybrid probe in different four times; A: 65msec, B: onset of H_α reduction, C: end of H_α reduction, and D: 85msec (with ETB).

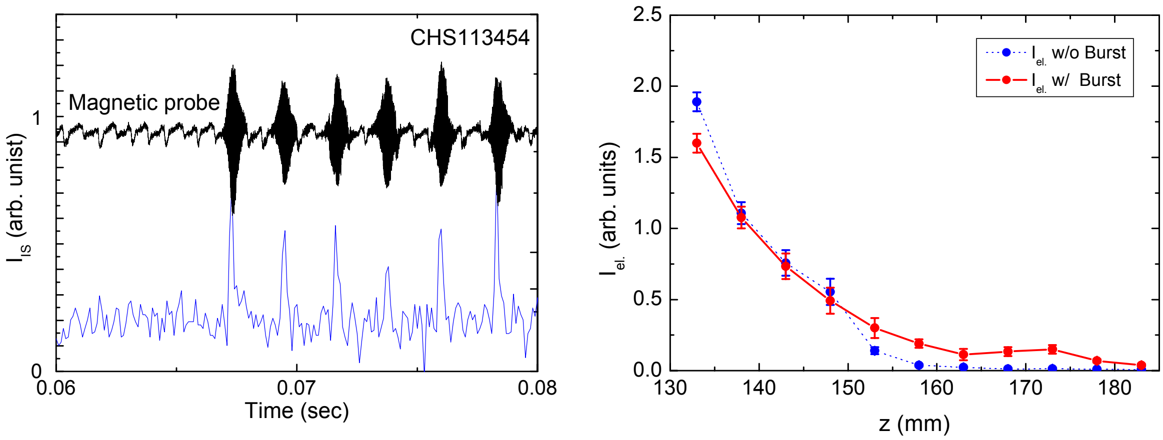

Figure 3. (a) Ion saturation current measured by the hybrid probe and signal of a magnetic probe. (b) Ion current profiles with and without the excitation of MHD burst.

the region 1180mm < *z* < 1195mm. There is little change between with or without ETB. In general, the ion saturation current is proportional to the plasma density and the square root of sum of electron and ion temperature, so the change of ion saturation current is considered to be mainly attributable to the change of plasma density. Thus it is concluded that the plasma density drastically increases at R<1200mm, and a steep density gradient is formed after H_α intensity reduction. Another characteristic of this transition is the slight decrease of the density just before H_α reduction in wide region near LCFS (case B in Fig. 2 (b)). However the clear decrease of flux is not observed in peripheral plasma in ETB phase, which is often observed in H-mode discharges in many devices. In standard configuration in CHS (Rax = 0.921m), LCFS touches the inboard wall of CHS vacuum chamber, that is, limiter configuration. It is considered as the most significant reason why the property of the peripheral plasma with ETB differs from that of H-mode discharges in other devices.

It is very important to focus on fluctuation characteristics before and after the formation of ETB. The significant decrease of density fluctuation was observed just before the onset of the H_α reduction, but it is not observed in ETB phase. It seems to be unique characteristics of the formation of ETB in CHS, and further study is necessary to understand these phenomena.

3-2 MHD burst In CHS, beam driven MHD bursts with mode number of m/n = 3/2 at Rax = 0.974m and m/n = 2/1 at Rax = 0.921m are excited, and loss of high energy particle related to the MHD bursts has been observed by lost ion probe measurement at only Rax = 0.974m [2,3]. The difference of the high energy particle loss between at Rax = 0.974m and Rax = 0.921m is understood by the difference of position of the MHD mode resonance, that is, the resonance position of m/n = 3/2 at Rax = 0.974m exists outside (ρ ~ 0.8), while that of m/n

= 2/1 at Rax = 0.921m relatively inside ($\rho \sim 0.6$). Thus the loss of high energy particle is clearly observed at Rax = 0.974m. The response of hybrid probe signal to the MHD burst was also observed at Rax = 0.974m, and it is shown in Fig. 3. At Rax =0.921m, that is not clear, and these results are consistent to those of measurement using the lost ion probe. The synchronized signal with the MHD burst was observed in not only ion current but also electron current of the probe, which implies that the response of the plasma synchronized with the MHD burst excitation is observed by the hybrid probe. The decreases of probe current with excitation of MHD burst were also observed near LCFS, and the spatial dependence of the response to the MHD burst was investigated, which is shown in Fig. 3(b). The plasma expands outward from near LCFS in synchronization with excitation of the MHD burst, that is, the plasma is also lost with MHD bursts at Rax = 0.974m in CHS.

4. Conclusions

The multipurpose probe (hybrid probe) was installed with two-dimensional probe drive in CHS. The changes of peripheral plasma characteristics with ETB formation and MHD bursts have been observed using this probe. The most advantage of this system is ability of spatial scan using two-dimensional probe drive and local measurement of plasma parameters without any line integration. The more detailed measurements in order to understand underlying physics of interesting phenomena and the measurement of heat flux in plasmas are next step of our study.

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