§8. Development of 3-D Microwave Imaging Diagnostic System (MIDS) in LHD

Nagayama, Y., Yoshinaga, T., Tsuchiya, H.,
Kuwahara, D., Tsuji-Iio, S. (Tokyo Tech.),
Yamaguchi, S. (Kansai Univ.),
Kogi, Y. (Fukuoka Inst. Tech.),
Ito, N., Mase, A. (KASTEC, Kyushu Univ.)

While the magnetic plasma confinement is highly affected by the turbulence and micro-instabilities, diagnostics for turbulence have not been well established. In this work, the microwave imaging diagnostic systems (MIDS) such as the Microwave Imaging Reflectometry (MIR) and the Electron Cyclotron Emission Imaging (ECEI) are developed in order to observe the electron density fluctuations and the electron temperature fluctuations, respectively. Fig. 1 shows schematic view of MIDS in LHD. MIR and ECEI use almost the same components. Differences are the frequency, the illumination wave and the phase detector. In LHD MIR uses the illumination wave with 4 frequencies (RF1: 60.410 GHz, RF2: 61.808 GHz, RF3: 63.008 GHz, RF4: 64.610 GHz) in order to observe 4 different plasma layers, but the frequency of ECEI is between 97 and 105 GHz.

Improved items in the 14th experiment campaign are as follows: (a) Reliability of the 7×7 Horn-antenna Mixer Arrays (HMA) is improved; (b) The vacuum window for MID makes slant in order to remove the interference due to the reflection at the window; (c) Mirrors are coated with nickel and are optically polished as the alignment using laser is reliable; (d) A frequency selective surface (FSS) is installed in front of HMA in order to reduce the ECH leakage of 77 GHz; (e) RF detectors making logarithmic output are installed to detect MIR amplitude. MIR uses 5 HMA arrays and ECEI uses 2 HMA arrays. Fig.2 shows a lower half part of the newly developed HMA. The HMA printed circuit board (PCB) is attached to a lower antenna frame in order to keep the PCB temperature lower.

Figure 3 shows a typical example of 3-D MIR image of the edge harmonic oscillation (EHO) in the case of standard operation (R_{ax}=3.6 m, B_{ax}=2.75 T, $n_{e0}=2.5\times10^{19}$ m^{-3}). EHO is a fluctuation in the edge plasma, and it was observed in the VH mode plasma in DIII-D when the ELM is absent. The feature of EHO is the frequency spectrum that consists of equally separated higher harmonics. Fig. 3 shows that EHO has a narrow structure along a field line. RF1, RF2, RF3 and RF4 correspond to R=4.56, 4.55, 4.54 and 4.525 m, respectively. The EHO is localized near the iota=1.5 surface, where R=4.525 m. Since the channel separation is 2 cm, the width of EHO may be 5 cm along the flux surface. Thickness of EHO in the radial direction is 2 cm, because it appears between RF1 and RF2. This is the first 3-D MIR measurement in the world.

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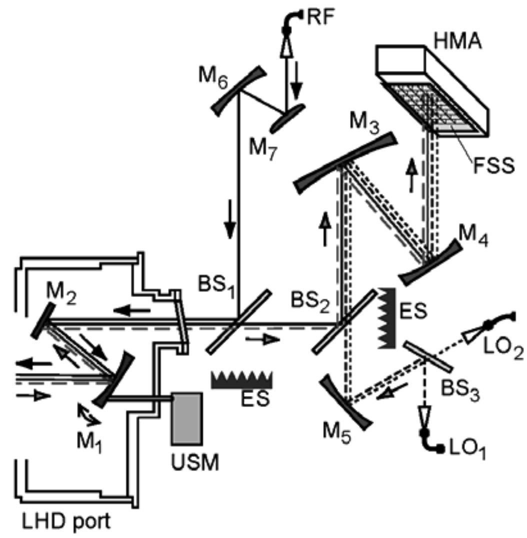

Fig.1 Schematic view of 3-D MIDS in LHD.

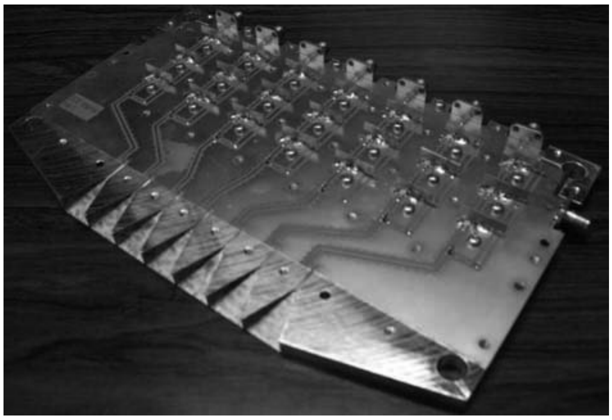

Fig.2 Lower half part of 7ch 1-D HMA.

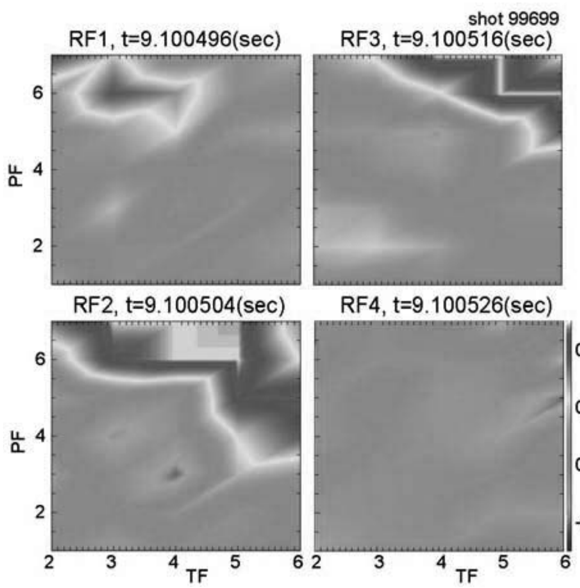

Fig.3 MIR image of EHO at four different RF frequencies. Channel separation is 2 cm.