§18. Application of ECE Imaging System to LHD

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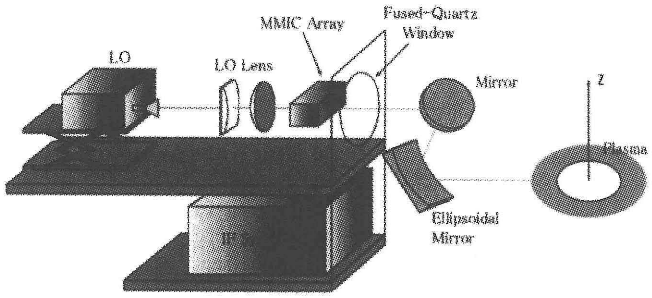

Fig. 1. Schematic view of the ECE imaging system.

In magnetically-confined plasmas, measurement of electron cyclotron emission (ECE) has become a main diagnostic to determine temporal and spatial behaviors of electron temperature. ECE imaging is a method whereby two-dimensional (2D) to three-dimensional (3D) images of temperature fluctuations as well as temperature profiles can be obtained. The ECE imaging has recently been applied to a tokamak plasma. We have developed a millimeter-wave imaging system for the application to LHD at the National Institute for Fusion Science.[1,2]

Figure 1 shows the schematics of the ECE imaging system attached to the diagnostic port of LHD. An ellipsoidal mirror and a plane mirror located inside the vacuum vessel converge the ECE signals to pass a fused-quartz vacuum window with a diameter of 192 mm. The sizes of the mirrors are determined in order to obtain desired resolution calculated using diffraction theory. An object plane located at the plasma center is 2.7 m in front of the ellipsoidal mirror. The magnification of the optics is 0.68.

The monolithic-type detector consists of the integration of a bow-tie antenna, down-converting mixer using a Schottky barrier diode, and hetero-junction bipolar transistors (HBTs) on a GaAs substrate. It is installed inside an aluminum box for electrical shielding, and a pyramidal horn antenna array in TE_{10} mode is attached to the both sides of the detector. The second-harmonic ECE signals in the extraordinary mode are mixed with an LO power on the detector array. The IF signals amplified by a chain of amplifiers (HBTs and main amp.: 1-8 GHz, 80 dB) are separated into four channels. Each signal is then band pass filtered. A range of filters is available with center frequency from 1 to 8 GHz at 1 GHz intervals; each has a 3 dB bandwidth of 300 MHz. The signal is then passed through a square-law detector.

The first experiment on LHD was performed from the end of January till the beginning of February 2001. Figure 2 shows the time evolution of the signal output of each IF channel (1 - 4 GHz) for the long time discharge (15 s) of LHD. During t=1.5-1.8 s, the ECRH power of 164 GHz is applied. The signal level after the ECRH pulse corresponds to the bulk electron temperature of the LHD plasma. The wideband characteristic of the detector is quite convenient for the application of correlation radiometry as well as the measurement of broadband spectrum with fixed LO frequency.

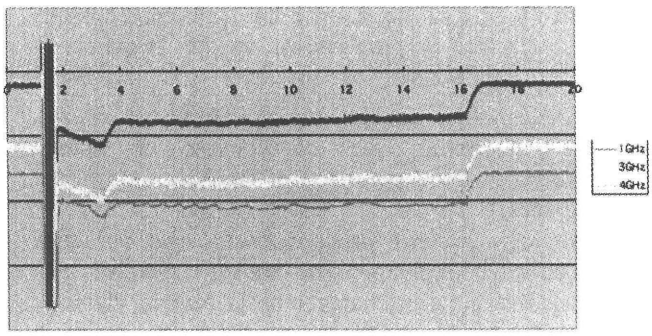

Fig. 2. Time evolution of the ECE signal obtained from each IF channel.

In the next experimental run (FY01), a dichroic plate will be inserted between the vacuum window and the detector in order to avoid the lower sideband of the second harmonic ECE. Also, A/D converters and a computer will be utilized for data handling to perform the correlation analysis between each IF signal.

References

1) Mase, A., Negishi, H., Oyama, K., Watabe, K., Mizuno, Nagayama, Y., Kawahata, Matsuura, H., Uchida, K., and Miura, A.: Fusion Eng. Design **53**(2001)87.
2) Mase, A., Ohashi, M., Yamamoto, A., Negishi, H., Oyama, N., Nagayama, Y., Kawahata, K., Watabe, K., Mizuno, K., Matsuura, H., Uchida, K., and Miura, A.: Rev. Sci. Instrum. **72**(2001)375.