§17. Development of Microwave Imaging Diagnostic System (MIDS) in LHD

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It is considered that the magnetic plasma confinement is highly affected by the turbulence and micro-instabilities. In the experimental work, 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 being 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 (60.410, 61.808, 63.008, 64.610 GHz) in order to observe 4 different plasma layers. The phase detector is used to detect the motion of the cutoff surface. The frequency of ECEI is higher than that of MIR. The local oscillation (LO) frequency of ECEI is 95 GHz, while that of MIR is 55.8 GHz. The frequency is separated by a dichroic plate with the cutoff frequency of 93 GHz for ECEI.

MIDS uses many channels of imaging detectors, frequency separators and IF amplifiers. In LHD, they are made of beam lead type electronics parts (resistor, capacitor, inductor, diode, MMIC, etc.) and thin Teflon printed circuit board (PCB) by using the micro-strip-line technology. Therefore those components can have the reasonable size and cost. The development of imaging detector is challenging. The microwave imaging system in the large helical device (LHD) uses the 7×6 Horn-antenna Mixer Arrays (HMA) for the V-band (50—75 GHz) detection. HMA has a good sensitivity more than 105 GHz. The optics is designed by using a FDTD simulation as the plane LO wave illuminates the HMA uniformly, and each channel of the antenna array is focused to a point of the object plasma. The mixer in HMA generates IF signal from the RF signal and LO wave. The illumination, signal and LO waves are separated with thin dielectric plate, of which reflectivity is plotted in Fig.2. A 1 mm thick acrylic plate splits the 93 GHz and 55.8 GHz LO waves, as the 93 GHz is passed and the 55.8 GHz is reflected.

Data analysis techniques (FFT, wavelet, Bicoherence, etc.) have been developed to study turbulence because waveforms of the signal of turbulence and noise are similar. Preliminary results are obtained in both MIR and ECEI. The edge harmonic oscillation (EHO) is observed in the case of high Ti operation as shown in Fig.3. Further improvements in the optics (M1 mirror control system, vacuum window, etc.) are required

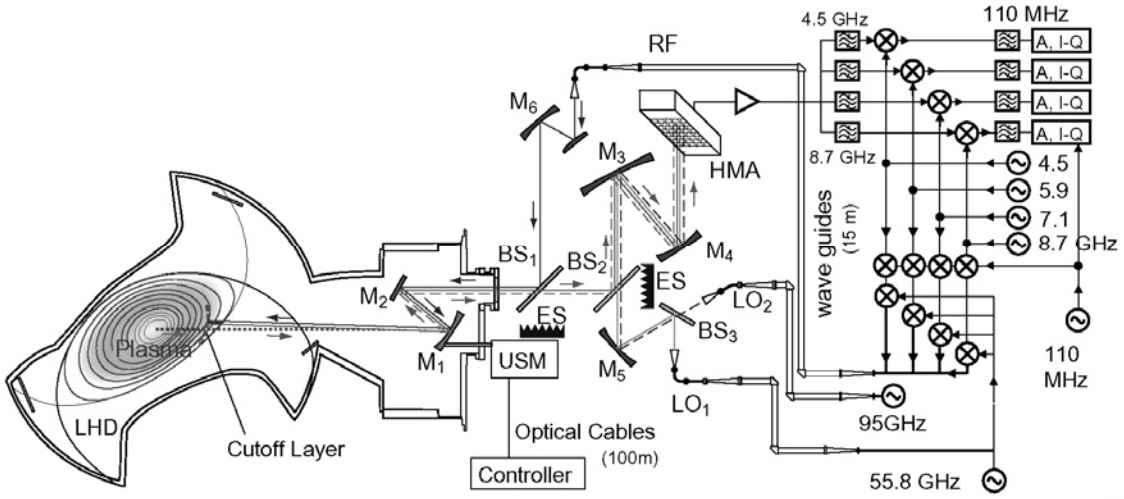

Fig. 1. Microwave Imaging Diagnostic System in LHD.

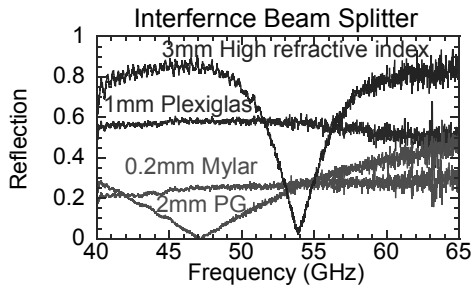

Fig. 2. Reflectivity of beam splitters.

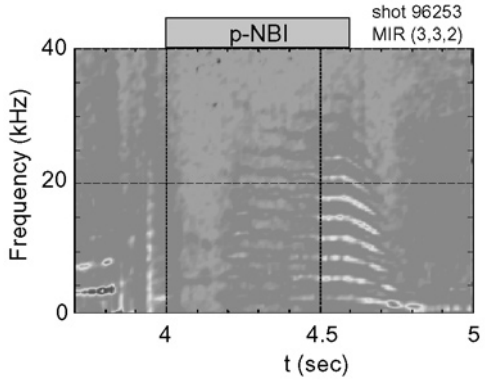

Fig. 3. FFT spectrum of MIR signal in the case of high Ti operation.