§4. Development of ECE Imaging System by the Use of 1-D Horn Antenna Array

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A combined system of Microwave Imaging Reflectometry (MIR) and the Electron Cyclotron Emission Imaging (ECEI) has been developed for Large Helical Device (LHD)[1]. Microwave imaging diagnostics has potential to observe the fluctuations of electron density and electron temperature profiles in magnetically confined high temperature plasmas. When the plasma density and temperature are sufficiently high, the intensity of Electron Cyclotron Emission (ECE) equals to the black body radiation in magnetically confined plasmas. The electron temperature profile can be determined by measuring the intensity of each frequency of ECE, since the ECE frequency corresponds to the radial position of emission. By using a 1-D receiving antenna array, 2-D ECE profiles (radial and poloidal directions) can be obtained. The electron temperature is considered to be equal on the same magnetic flux surface so that ECEI can be one of the most powerful diagnostics to investigate MHD instabilities.

We have developed a 1-D horn antenna array (HMA) as 2-D receiver array of both MIR and ECEI. A 2-D antenna array can be assembled by stacking 1-D HMA[2]. The HMA consists of four parts, horn antenna, waveguide, mixer and IF amplifier. The ECE radiating from plasma and local oscillation (LO) wave enter through horn antenna, and down-convert into mixer passing through the waveguide. The ECE signals down-converted into IF signals in the frequency range of 2 – 9 GHz are amplified with IF amplifier, and power spectrum is obtained with multi-frequency detector. In this HMA, the use of LO optics is necessary to supply the LO wave to the mixer. However, the LO optics decreases the intensity of ECE wave because of scattering by a beam splitter shown in Fig. 1.

To eliminate the LO optics, we have been developing a new HMA. Figure 2 shows schematic drawing of new HMA. The new HMA consists of six parts, LO dividers, and LO frequency multiplier and four parts from the former HMA. At the new HMA, the observation LO and IF frequencies are 60.110 GHz, 60 GHz and 110 MHz, respectively and the channel number is eight. The LO wave is injected in HMA with a coaxial cable at the frequency of 1/4 LO signal, 15 GHz. This frequency range is easy to transmit with low losses with coaxial cable and coaxial connector. The 1/4 LO signal is divided to eight with LO power dividers placed on the back side of a printed circuit board. The frequency of divided 1/4 LO signals are quadrupled with microwave monolithic ICs at each channels.

And a fin-line waveguide to microstrip-line (WG-MSL) transmission will be upgraded for the new HMA. Figure 3 indicates transmission losses of four types of WG-MSL transmission. The transmission losses seems less than -6 dB, it is smaller than the former transmission.

For the next experimental campaign of LHD, we will develop an evaluation HMA and will install our microwave imaging systems.

1) Nagayama, Y. et al.: Rev. Sci. Instrum., **83**, 10E305 (2012).
2) Kuwahara, D. et al.: Rev. Sci. Instrum., **81**, 10D919 (2010).

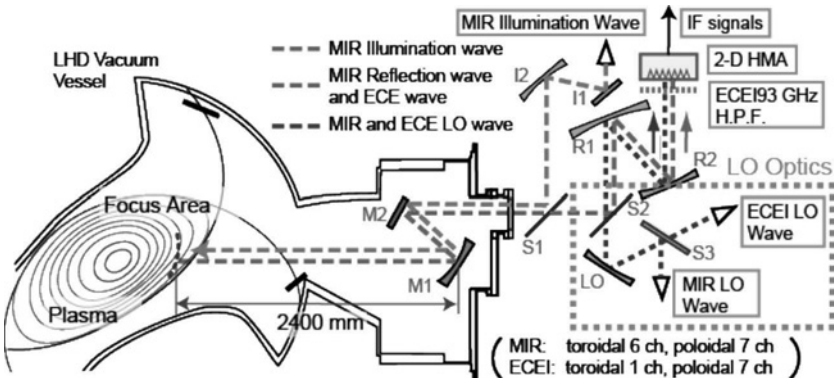

Figure 1 Optics of MIR and ECEI system.

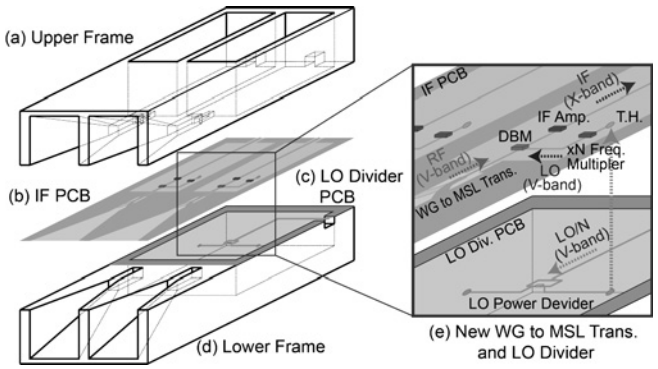

Figure 2 Schematics of New HMA. (ex. 2 channels)

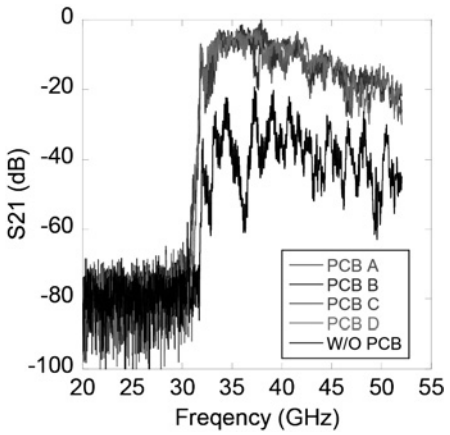

Figure 3 Transmission losses of waveguide to microstrip-line transmission.