Development of 2-D Antenna Array for Microwave Imaging

D. Kuwahara, S. Tsuji-Iio, Y. Nagayama[a], T. Yoshinaga[a], Z.B. Shi[b], S. Yamaguchi[c], S. Sugito[a], K. Akaki[e], Y. Kogi[d] and A. Mase[e]

Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku 152-8550, Japan
[a] National Institute for Fusion Science, 322-6 Oroshi-cho, Toki 509-5292, Japan
[b] The Graduate University for Advanced Studies, 322-6 Oroshi-cho, Toki 509-5292, Japan
[c] Kansai University, 3-3-35 Yamate-cho, Suita 564-8680, Japan
[d] Fukuoka Institute of Technology, 3-30-1 Wajiro-Higashi, Fukuoka 811-0295, Japan
[e] Kyushu University, 6-1 Kasuga Koen, Kasuga 816-8580, Japan

Kuwahara.daisuke@LHD.nifs.ac.jp

The microwave imaging has been expected as one of the most powerful diagnostics of fluctuations. The Microwave Imaging Reflectometry (MIR) is a system that illuminates the plasma with the microwave and projects the microwave image of the cutoff surface onto the 2-D imaging detector array with an optical system. Since MIR enable us to obtain 2-D/3-D images of electron density fluctuations, it is useful to investigate turbulences and magneto-hydrodynamic (MHD) instabilities. The plasma radiates microwaves at harmonic frequencies of the electron cyclotron frequency. This is called the Electron Cyclotron Emission (ECE). By using optics, the ECE image can be also projected onto the 2-D imaging detector array. Since the radiated microwave intensity is proportional to the electron temperature, the Electron Cyclotron Emission Imaging (ECEI) is beneficial to obtain 2-D/3-D images of electron temperature fluctuations. Hence ECEI is powerful to investigate MHD instabilities. In order to obtain mode numbers in the toroidal, the poloidal and the radial directions, it is necessary to use four or more frequencies as probe waves and four or more antennas placed in the toroidal and poloidal directions for both MIR and ECEI.

One of the most important devices of the microwave imaging is the 2-D imaging detector array. We have developed an array of pyramidal horn antenna with printed circuit on a Teflon film using the micro-strip-line technology. On the Teflon film circuit, a surface mounted Schottky diode is located at the horn antenna element and low-cost GaAs microwave monolithic IC (MMIC)s. The local oscillation (LO) microwave also illuminates the detector array and the Schottky diode down-converts the microwave to an intermediate frequency (IF) signal. The IF signals are amplified with the MMICs on the Teflon film circuit to be sent to the band-pass filter banks to separate different frequency components.

We have been developing an 8×5 2-D imaging detector array for MIR. It has a flat frequency response in the frequency range of 50 – 75 GHz (V-band). Recently, we have been developing a 2-D imaging detector array for the ECEI. The LO frequency is 95 GHz for ECEI. The upper side-band of the LO frequency should be taken in ECEI since the IF frequency from the lower side-band and the upper side band cannot be separated. Consequently, a high pass filter whose cutoff frequency is slightly lower (by about 2 GHz) than the LO frequency is required. There may be two solutions, a waveguide filter at each antenna element, and a dichroic filter in front of the antenna array. An antenna with a waveguide filter of 93 GHz between horn and mixer section has been tested. On the other hand, the V-band detector array also has a high gain at 95 GHz. A high-pass filter in front of the detector array may be a good solution since fabrication of the front end high-pass filter is much easier than that of a waveguide filter in the detector array. The details of the 2-D imaging detector array will be presented at the conference.