§33. Measurement of Electron Bernstein Wave Emission from Ultra High Beta Plasmas

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Plasma current-drive technique to enable steady state operation of a low-q plasma discharge proposed by Hassam [1] utilizes the Nernst effect. If a plasma has a steep radial temperature gradient, the cross-field thermoelectric force is in the opposite direction to the usual resistive friction, thus maintaining the plasma current. In low-q plasmas such as a field reversed configuration (FRC), however, maintaining the electron temperature profile is difficult because of its high beta property. Although electron cyclotron resonance heating (ECRH) is a very powerful method to heat magnetically confined plasmas, the accessible plasma density is limited by a critical density. Electron Bernstein wave (EBW) is considered as a possibility for overcoming the density limit. In order to investigate the possibility of heating an extremely high-beta plasma by EBW, we have developed a diagnostic system of electron Bernstein wave emission (EBE), which is an inverse process of mode conversion of EBW heating.

Figure 1 shows poloidal flux contour (top), radial profiles of magnetic field strength (middle) and electron density (bottom) of the TS-4 FRC plasma. Magnetic field of 0.01 T confines a plasma with density in the order of $10^{20}$ m$^{-3}$, indicating extremely overdense medium $n_{pe}/n_{Te}$>100. Because the density gradient at edge of TS-4 FRC is sufficiently steep at the location of the UHR layer, the UHR layer can come close enough to the right-hand cutoff, so that some of the power trapped in the plasma can tunnel through to electromagnetic, X-mode branch. This is the mode conversion process we expect. Figure 2 is schematic of the EBE measurement system we had developed in this year for TS-4 plasmas. Frequency which can be measured by our system is resonant with the sixth or seventh electron cyclotron layer near the plasma edge. The electromagnetic wave emitted from TS-4 plasmas is received by a waveguide antenna and transmitted to a detector module through a waveguide-coaxial cable converter, coaxial cable, attenuators and amplifiers. The detector module surrounded in a bold line frame in Fig. 2 was fabricated using microwave integrated circuit (MIC) technology by Mase laboratory Kyushu University [2]. Employment of the MIC technique had downsizing of the system and cost reduction of development enabled. Figure 3 shows transmission performances of the band-pass filters. The frequency range is 2-5.1 GHz and 500 MHz of bandwidth is achieved in each channel.

According to a numerical calculation based on the cold plasma resonance absorption model, in an optimal condition of receiving angle and polarization, conversion efficiencies of 30 % for 2.45 GHz and 50 % for 5.0 GHz are expected in TS-4 FRC. We are to initiate the measurement of EBE from TS-4 FRC and compare the experimental results with the calculation.