§39. Ultra-Short Microwave Pulse for Plasma Diagnostics

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Microwave diagnostics are standard techniques in plasma experiments. Microwave reflectometry is one of the most active fields where many new ideas are developed and applied. Here we report two reflectometers; one uses ultra-short microwave to measure density profile, and the other is used with a radiometer composing an Electron Bernstein Wave (EBW) temperature measurement system.

A voltage impulse can be used as a wide-band microwave source. Using this source, it is possible to make simple and compact microwave diagnostics, which can be very complicated system with conventional sources. A reflectometer using a voltage impulse (3V/22ps) has been applied to inductively coupled steady state plasmas (ICPs). The reflected wave is recorded on a sampling scope with 50 GHz bandwidth. While the standard method uses only the phase information of the reflected wave, the recorded waveform has more information. To use all the information, we have developed a new method: Signal Record Analysis to derive the density profile (Fig.1). Using this method, the accuracy and stability of the analysis has been improved significantly.

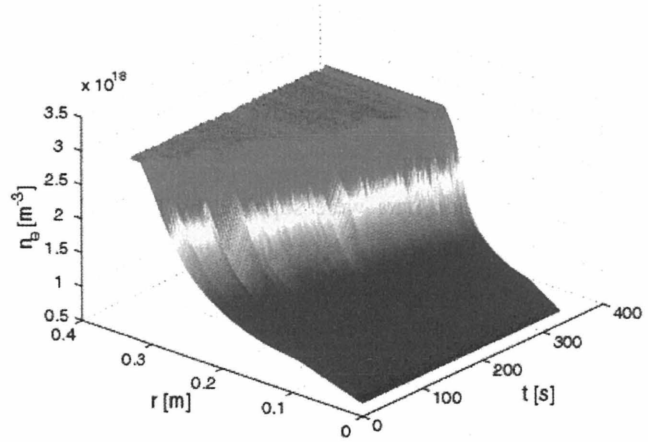

Fig. 1. Time evolution of the density profile of ICP.

In order to apply the same method to LHD plasmas, which have much higher density than ICPs have, we have to shift the frequency. The target frequency range is 60-90GHz, which covers the whole plasma using O- and X-modes. This is made by the following four stages; (i)impulse (3V/22ps) generation, (ii)waveguide propagation to limit the frequency range to 8-18 GHz, (iv)frequency up-conversion to 71-81GHz range by mixing with a 63GHz source. The obtained microwave pulse is launched and reflected by a mirror, and it is down-converted using the 70GHz source. The down-converted wave is recorded and it is confirmed that it has the components of 1-11 GHz.

While ECE measurement is a standard technique to measure electron temperature, ECE suffers from cutoff in relatively high density and low field plasmas. In those situations, EBW, the intensity of which is proportional to the electron temperature, can be used for the temperature measurement. The wave is electrostatic mode, it should be mode-converted to electro-magnetic wave to be emitted from the plasma via mode-conversion. Therefore, the mode-conversion efficiency, which depends on the density profile, should be measured by other method. A system which consists of a radiometer and a reflectometer has been made to measure the EBW emission, and the mode-conversion efficiency simultaneously (Fig.2). By the reflectometer the density profile was measured and the efficiency was calculated. We have found that the efficiency can be also estimated from the reflectivity of the launched wave. The system has been installed on the TST-2 spherical tokamak. The efficiencies measured by the two methods agree well, thus the system is proved to be a reliable electron temperature measurement system.

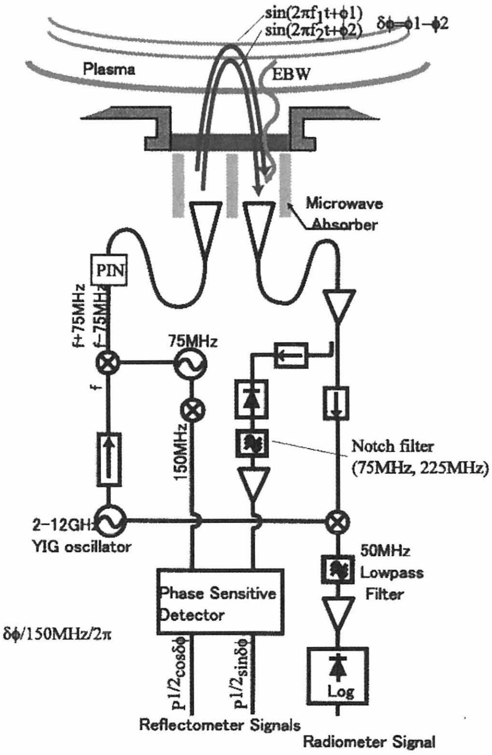

Fig. 2. A radiometer-reflectometer system to measure the electron temperature from EBW emission.