§11. Study of Potential Confinement Mechanism via Plasma Visualization Technology

Mase, A., Kogi, Y., Ignatenko, M. (KASTEC, Kyushu Univ.)
Yoshikawa, M., Itakura, A., Nakahara, A., Hojo, H., Cho, T. (PRC, Univ. Tsukuba)
Nagayama, Y.

In tandem mirrors, an electrostatic potential is created in order to improve axial confinement. The radial electric field $\boldsymbol{E}_r$ due to this potential causes a $\boldsymbol{E}_r \times \boldsymbol{B}$ plasma rotation in the direction of the ion diamagnetic drift velocity. The verification of the effect of $\boldsymbol{E}_r$ is one of the most critical issues to understand the physics basis for recent confinement improvement. Understanding the mechanism of this effect requires the use of sophisticated diagnostic tools for measurement of plasma profiles and their fluctuations. Recently, numerous studies have stressed the need for high resolution imaging diagnostics, which will permit the visualization of 2D and 3D structures of plasma parameters such as electron density and temperature. Significant advances in microwave and millimeter wave technology have enabled the development of a new generation of imaging diagnostics as visualization tool in this frequency range. This report describes the development of millimeter wave imaging diagnostics applied to the GAMMA 10 tandem mirror.

In this fiscal year, we have operated a phase-imaging interferometer (PII) installed in the plug region. The PII consists of a quasi-optical transmission line with parabolic and ellipsoidal mirrors and heterodyne receiver with a frequency of 70 GHz and is comprised of a 4×4 hybrid detector array with the 16 elements of beam-lead GaAs Schottky barrier diodes bonded to bow-tie antennas on a fused-quartz substrate. A scalar-feed horn produces a symmetric radiation pattern with low side lobes, which is well fitted by a Gaussian distribution. The cross section of the probe beam is 200 mm × 200 mm at the plasma center. The receiving optics, an ellipsoidal mirror, a flat mirror, and polyethylene lenses, are designed by using a ray-tracing method to focus radiation signals onto a 2D detector array. The quadrature-type detection system provides the phase difference between two intermediate frequency (IF) signals obtained by mixing the transmitted signal (RF) and the local oscillator signal (LO). The phase difference is proportional to line density of plasma.

Since the number of the quadrature phase detector is limited to 4 in the present stage, at least 4 plasma shots with good reproducibility are needed to obtain a full 2D profile. The time evolution of the line density obtained by one of the channels is shown in Fig. 1(a). The changes of the 2D line-density profiles during the plasma shot are shown in Fig. 1 (b) and (c). When the ECRH power is applied to the plug cell plasma at t=180 ms, the confining potential is created near the position of z=962 cm where the magnetic field strength equals to 1 T. At the region of z=971 cm where the imaging system is installed, the loss particles decrease due to the formation of the confining potential. When the ECRH is turned off at t=200 ms, the confining potential disappears, and a short burst appears in the line-density signal corresponding to the axial drain of the plasmas. The variation of the profile in the axial direction is caused by the change of the magnetic field.

We are developing a new type of imaging antenna named double balanced mixer antenna (DBMA). The DBMA has electrically similar structure to doubly balanced mixer. Two sets of baluns in the DBM act as two dipole antennas in DBMA. Each antenna is arranged perpendicularly in order to detect RF and LO waves with different polarization. The IF signals generated in ring quad diodes are combined directly outside of the DBMA via RF rejection choke coils. The characteristics of the antenna is have been tested at the frequency of 70 GHz. We plan to replace present imaging antenna, bow-tie antenna, to DBMA in FY2005.

In order to upgrade the imaging system to imaging reflectometer, the numerical study of microwave imaging reflectometry (MIR) has been started. The parameter of focusing optics, such as lens aperture size and the effect of misalignment has determined for the central cell MIR system.[1)]

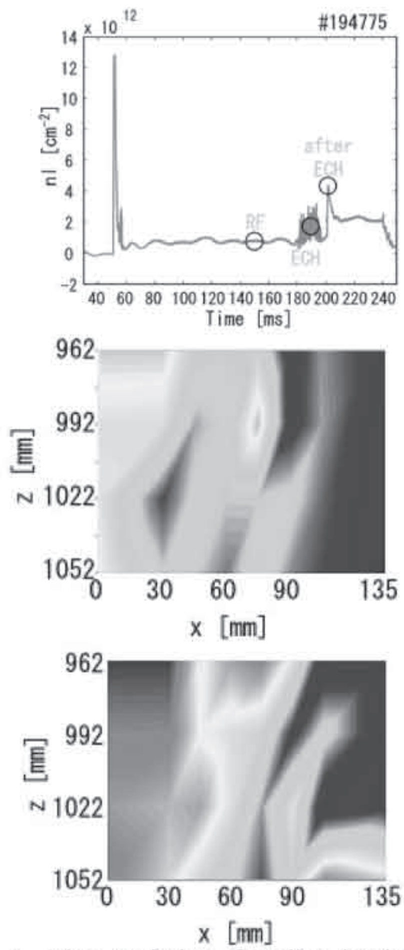

Fig.1 Time evolution of 2D line density profiles.

Reference
1) Ignatenko, M., Mase, A., Bruskin, L., Kogi, Y., and Hojo, H., Trans. Fusion Sci. Tech. **47**, 183 (2005).