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Construction of Microwave Imaging Interferometer System for Divertor Simulation Experiments in GAMMA 10/PDX

GAMMA 10/PDXダイバータ模擬実験のための マイクロ波イメージング干渉計システムの構築

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In GAMMA 10/PDX, divertor simulation studies have been started using a divertor simulation experimental module (D-module) installed in the west end-cell. A new interferometer system with 1-D horn-antenna mixer array (HMA) utilizing phase imaging method has been developed and first applied to observe line-averaged electron densities and density distributions in the core region of D-module.

1. Introduction

In GAMMA 10/PDX, divertor simulation experiments have been started as a new research plan by utilizing plasma flux flowing toward the end of the linear machine. For this purpose a divertor simulation experimental module (D-module) [1,2] was installed in the west end-cell of GAMMA 10/PDX as shown in Fig. 1. D-module has a rectangular chamber (500 × 480 mm, 700 mm in length) with an inlet aperture. Two tungsten plates (350 × 300 mm) are mounted in V-shape inside the chamber. The open-angle of the V-shaped target can be changed from 15 to 80 degree. Gas injection lines are installed for investigation of radiation cooling and plasma detachment.

Several diagnostic tools are utilized to investigate plasma parameters in D-module, for example, a high-speed camera for 2-dimensional image measurement of visible emission from plasma-target interactions, Langmuir probes and spectrometers for electron temperature and density measurements. In order to obtain precise electron densities and density distributions including core plasma region in D-module, we have newly developed a microwave interferometer system using phase imaging method with 1-D horn-antenna mixer array (HMA) [3,4].

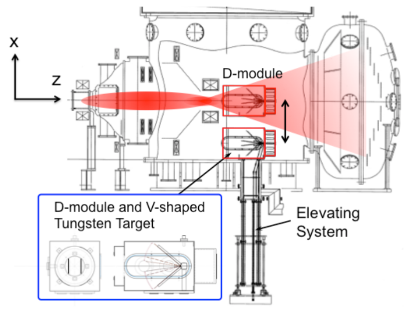

Fig.1. Schematic view of GAMMA10/PDX west end-mirror cell and D-module.

2. Newly installed microwave interferometer system with 1-D horn-antenna mixer array

Basic system design of transmitting and receiving lines is similar to that of previously developed single channel interferometer system using frequency multipliers [5] as shown in Fig. 2. Microwave source is a 15 GHz internal phase locked dielectric resonator oscillator (PLDRO). The source signal is split into the probing beam and the reference beam. The probing beam is up-converted by a single sideband (SSB) upconverter with 37.5

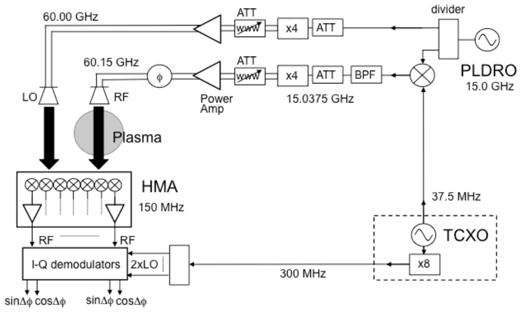

Fig.2. Schematic diagram of the microwave source and receiver system.

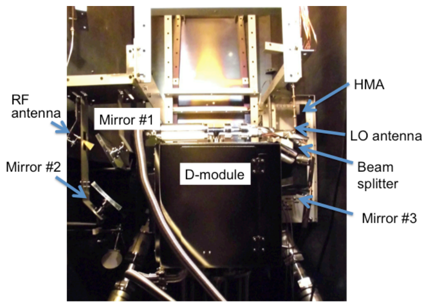

Fig.3. New interferometer system and D-module installed inside GAMMA10/PDX.

MHz signal from a temperature-compensated crystal oscillator (TCXO). The TCXO also provides a 300 MHz signal (*i.e.,* the octupled frequency of 37.5 MHz) for a 2×LO input of I-Q demodulators [3,4]. Remaining lower sideband component and LO leakage in the probing signal after upconversion are eliminated by a band-pass filter (BPF) having center frequency at 15.0375 GHz. The probing signal and the reference signal are frequency multiplied by active quadrupler to 60.15 GHz and 60.00 GHz, respectively.

Figure 3 shows the newly installed interferometer system and D-module inside the GAMMA 10/PDX vacuum vessel. The probe wave from the RF antenna passes through the plasma in D-module as a parallel beam by using two mirrors. The beam propagates oblique to the z-axis of GAMMA 10/PDX. The transmitted beam is detected together with the reference beam from the LO antenna by HMA. HMA consists of an upper and a lower aluminum frames. A set of upper and lower frames makes pyramidal horn antennas and rectangular waveguide sections. Inside HMA is a thin printed circuit board (PCB) with Schottky barrier diodes (SBD). SBD mixes the transmitted waves and LO waves and generates the intermediate frequency (IF) signals of 150 MHz. IF signals are amplified by monolithic microwave integrated circuits

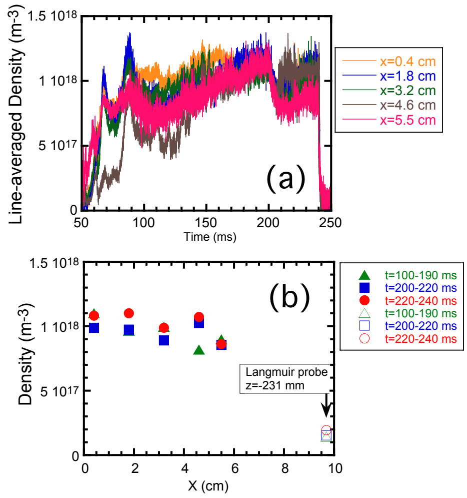

Fig.4. (a) Time behavior of line-averaged electron density and (b) line-averaged density distribution with local densities obtained by Langmuir probe on the V-shaped target.

(MMIC) on the PCB.

3. Experimental Results

The interferometer was first applied to measure densities in the core region (x<6 cm) of the plasma in D-module. Figure 4(a) shows the time evolution of line-averaged electron densities obtained by the interferometer in H_2 gas injection experiments. Here the plenum pressure of the reservoir tank is 400 mbar. The open angle of the V-shaped target is 45°. Figure 4(b) represents the profile of time-averaged densities obtained by the interferometer during three different heating conditions. Local densities obtained by the Langmuir probe on the V-shaped target are also plotted for reference in Fig. 4(b). In this experiment the line-averaged densities in the core region are larger than local densities near the target by a factor of 4~8.

Acknowledgments

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