§5. Direct Phase Measurement of Phase Correcting Mirror-Array in Matching Optics Unit

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In our gyrotrons which have been prepared for LHD experiments, c-axis sapphire and silicon nitride material are used at the gyrotron windows. In this case, the intensity pattern radiated from a gyrotron should be flatter than that of a Gaussian beam at the gyrotron window , to reduce the power surface-density there. In order to couple to the waveguide transmission lines, this output beam is converted to the Gaussian beam at Matching Optics Unit(MOU). If a fine Gaussian beam, whose size is suitable to couple to a HE_{11} mode in the waveguides, is taken under this conversion, and the beam is aligned correctly, a high coupling efficiency between the gyrotron output and the waveguides is expected.

For our 84GHz gyrotron, a phase Matching mirror-array in MOU was designed to get the high efficiency under a collaboration with MIT. The intensity pattern radiated from gyrotron were measured using IR camera at various planes along the propagating axis [1]. In the design, the phase patterns of the propagating wave were retrieved from the intensity patterns measured along the propagating axis to be explained. Using this retrieved phase, the mirror surfaces were determined. In order to check a performance of the array, a new low power test facility that is composed of synthesizers, a network analyzer, a 3 dimensional translator stage. The Phase Pattern retrieved in the calculation is directly compared to the measured pattern. In the array design, 4 mirrors are used for the beam to couple to the waveguides. The first and second mirrors from the gyrotron window are the phase correcting mirrors, and the others are quasi-optical mirrors. Since the rather complicated flat pattern at the window can not be prepared for the low power test, a inverse conversion is investigated with the well-defined Gaussian beam. The Gaussian beam whose beam parameters are similar to those in calculation is injected to the second mirror after reflections at fourth and third mirrors. This Gaussian beam should be converted to the rather complicated flat pattern after a reflection at the first mirror. In low power test, the waist size at the second mirror in the x and y directions which are perpendicular to the propagating z axis are 59mm and 74mm, respectively. In the calculation, the waist size are 59mm and 76mm in the directions. The intensity and phase patterns both of the calculation and the measurement at 1cm from the window are shown in Figures 1 and 2. In the intensity pattern, there are differences in the fine structures, but those features, for instance, the flatness near the beam center, the position of the centers and the beam sizes are similar. The rapid change of the phase, in particular in the y direction, indicated that the beam is strongly expanding after the radiation from the gyrotron. To discuss the measured intensity and phase pattern in detail, the calculation using a physical optic code is necessary, taking into account the experimental beam parameters and setting

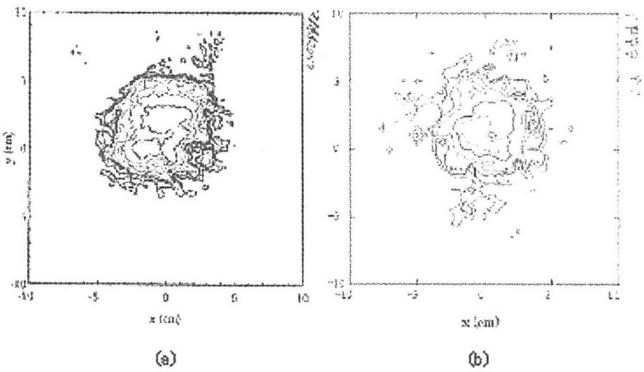

Fig.1. Intensity patterns calculated (a) and measured (b).

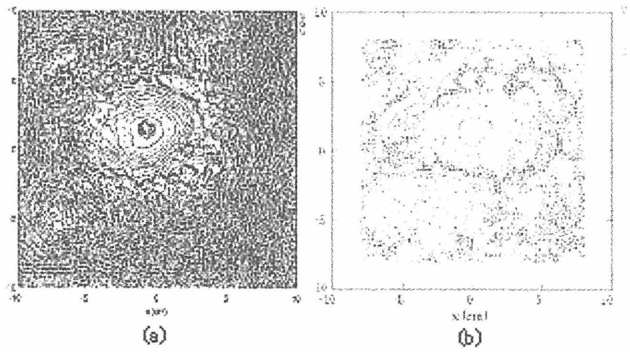

Fig.2. Phase patterns calculated (a) and measured (b).

Reference

1) Shimozuma,T., NIFS Annual Report(1999)
2) Notake, T., In this Annual Report