Theoretical and experimental investigations on the coaxial gyrotron with two electron beams

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***Abstract*—Theoretical and experimental investigations on the coaxial gyrotron with two electron beams has been carried out. The output power is measured with a calorimeter. The operating frequencies are measured with a detector and a frequency mixer simultaneously. The experimental results agree well with the theoretical predictions. The quasi-optical mode convertor for dual-frequency operation coaxial gyrotron with two electron beams to separate the output power with two different frequencies efficiently is designed.**

I. INTRODUCTION

THE study on gyrotrons remains to be one of the most attractive topics for the following applications such as plasma diagnostics, electron-spin resonance spectroscopy, enhancement of NMR sensitivity using dynamic nuclear polarization, standoff detection and imaging of explosives and weapons, new medical technology, atmospheric monitoring chemical technologies, and production of high-purity materials. To improve the gyrotron performance, the coaxial gyrotron with two electron beams (CGTB) is proposed and investigated. Theoretical and numerical studies show that CGTB could improve mode competition and enhance output power. The dual-frequency operation is a special operation of CGTB: one beam works at the fundamental cyclotron harmonic (ω_c) while another at higher cyclotron harmonic ($l\omega_c$) in one cavity. Dual frequency radiation can be obtained by using one gyrotron.

Fig.1 The prototype of CGTB

The quasi-optical mode convertor for dual-frequency operation CGTB mainly consists of an antenna as a launcher, a quasi-elliptical mirror which focuses the beam transversely; a quasi-parabolic mirror which focuses the beam longitudinally and a filter based on frequency selective surface which separate the two different-frequency linearly polarized beams efficiently.

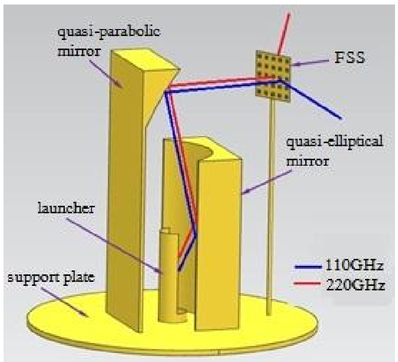

Fig.2 Schematic of the quasi-optical mode convertor for dual-frequency operation CGTB

II. RESULTS

A test facility has been built to check the performance of the dual-frequency operation CGTB. The measurement devices consist of a calorimeter which is used to measure the pulsed output power and converts a pulsed power signal into a pulsed voltage signal, a detector which is used to detect the signal operating at the fundamental cyclotron harmonic, and a frequency mixer to measure the frequency at the second cyclotron harmonic. The measurement result of the output power with a calorimeter is shown in Fig. 3.

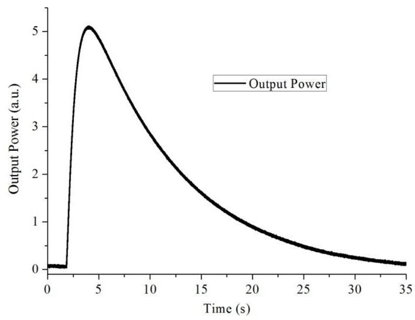

Fig. 3 the measurement result of the output power

The experimental setup to measure the frequencies is shown in Fig. 4. Fig. 5 shows the results of the frequency measurement of the dual-frequency operation CGTB. The red line is the signal detected by the detector which is used to detected the fundamental cyclotron harmonic signal; the blue line is the IF signal from the frequency mixer which is utilized to measure the second cyclotron harmonic signal; the yellow line is the pulsed high voltage of the dual-frequency operation CGTB.

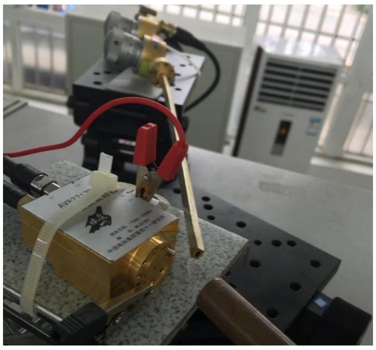

Fig.4 The experimental setup for frequency measurement

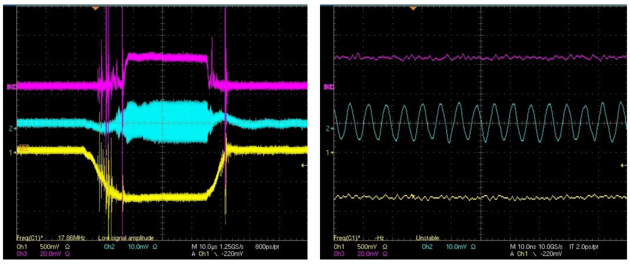

Fig. 5 the measurement results of the operation frequencies of the dual-frequency operation CGTB

For the operation modes TE_{02} and TE_{04} in the dual-frequency operation coaxial gyrotron with two electron beams, they have the similar Brillouin angle θ_B, the same caustic radius R_c, and the similiar launcher cut length L_c, so the quasi-optical mode convertor can efficiently convert these two modes into linearly polarized Gaussian beams simultaneously, and these two different-frequency linearly polarized Gaussian beams are superposed at the output window, as shown in Fig. 6. The theoretical predictions of the power conversion efficiency are about 85% for TE_{02} mode and 90% for TE_{04} mode.

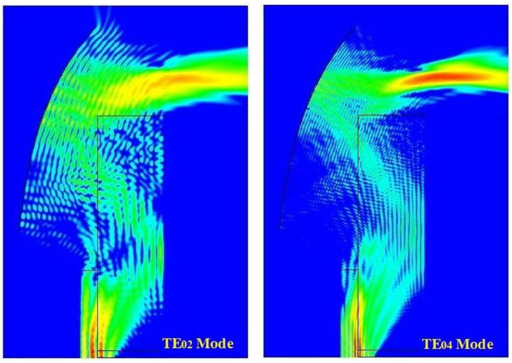

Fig. 6 Cross section of the QO mode convertor for DFO CGTB with electric field from 3-D simulation

III. Summary

The theoretical and experimental investigations on the coaxial gyrotron with two electron beams have been carried out. The output power and the operation frequencies have been measured with a calorimeter, a detector, and the frequency mixer, separately. The experimental results agree well with the theoretical predictions.

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