Stabilization of high frequency gyrotron output
高周波ジャイロトロンの発振出力の安定化

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High frequency gyrotrons are the most promising candidates for high power radiation sources in millimeter to submillimeter wavelength range. In some applications, the output of a radiation source needs to be kept constant for a long time. Gyrotron output power depends on beam current. As the first step, the beam current was stabilized by feedback control. The fluctuation level of output power has been reduced from 15% to 2% by the feedback control.

1. Introduction

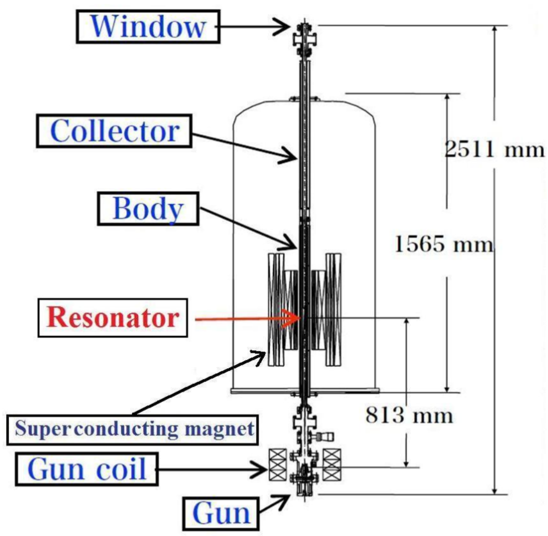
High frequency gyrotrons are characterized by their ability to deliver high powers in millimeter to submillimeter wavelength range. For many applications where more intense radiation is required, the gyrotrons are the most promising candidates for radiation sources in this range of the electromagnetic spectrum. Gyrotron FU CW Series [1] were developed as high power CW radiation sources in our research center FIR FU.

In some applications, the output of a radiation source needs to be kept constant for a long time. Gyrotron output power depends on beam current and voltage between cathode and anode. Ripples of cathode and anode voltage produce the fluctuation of gyrotron output power. The fluctuation of the output power in a short time interval (~several seconds) was decreased from 4 % to 1 % by introducing the smoothing circuit consisting of a resistor, an induction coil and a capacitor [2]. The change of beam current brings about slow fluctuation of the output power. It is necessary to remove this beam current fluctuation for a long time stabilization of the output power. The fluctuation of the beam current is effectively adjusted by changing heater voltage. The fluctuation level of output power has been reduced by the feedback control to adjust beam current.

2. Gyrotron FU CW III

Gyrotron FU CW III [3] is one of gyrotron device belongs to Gyrotron FU CW Series. Figure 1 shows the cross section and the side view of Gyrotron FU CW III. The gyrotron device consists of a 20 T superconducting magnet, three gun coils and gyrotron tube. The gyrotron tube consists of a triode electron gun, a sapphire window and a cavity. The installed cavity has the same dimensions as that of the THz pulse gyrotron [4]. The cavity is a simple cylinder and that of the radius and the length are 1.95 mm and 10 mm (Fig.2), respectively. The designed cavity mode is $TE_{4,12}$. The frequency is 1.013 THz and operation is at second harmonic operation.

Fig. 1. Gyrotron FU CW III



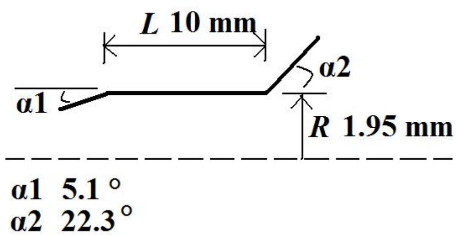


Fig. 2. The shape of cavity.

3. Experimental results

The experimental test was carried out under the following conditions: TE_{03} mode, f=248.72 GHz, P~20 W, magnetic field intensity in the cavity region B_0=9.05 T, cathode potential V_k=-17.6 kV, anode potential V_a=-13.95 kV. The gyrotron device is connected with cathode and anode power supplies (Fig. 3). The beam current is adjusted by changing heater voltage (Fig. 4).

The beam current gradually increases and decreases with the time (the upper trace of Fig. 5). The beam current fluctuates up to 17% in the time interval of 4000 s. This fluctuation level is decreased to 0.5% by the feedback control to adjust heater voltage (the lower trace of Fig. 5).

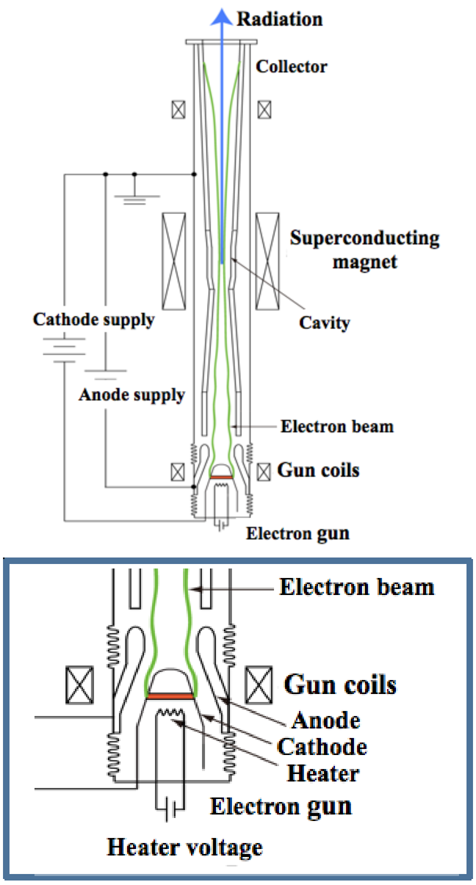


Fig. 3. Connection of power supplies with gyrotron device.

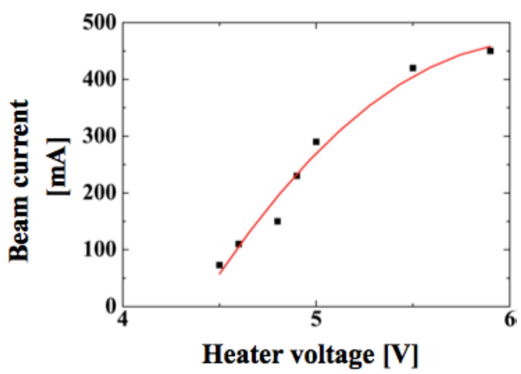


Fig. 4. Beam current as a function of heater voltage.

The output power also changes with the time (the upper trace of Fig. 6). The fluctuation level of output power is about 15%. By the feedback control of the beam, the fluctuation level of output power is decreased to 5%. If the gyrotron output power depends on only the beam current, more effective stabilization of output power will be realized to the level of 0.5%. This result has suggested that not only change of beam current but also other causes bring about change of output power. This is understood from more effective stabilization up to 2% being attained by carrying out feedback control to adjust heater voltage of the output power (the lower trace of Fig. 6).

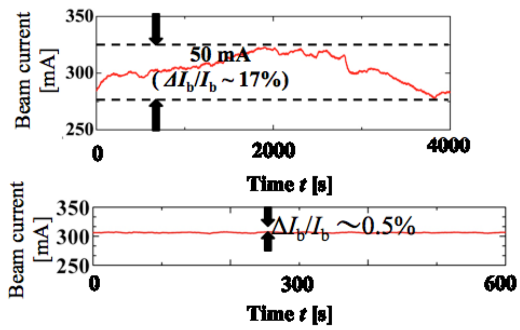


Fig. 5. The time evolutions of beam current. Upper trace corresponds to free running of gyrotron operation. Lower trace corresponds to feedback control.

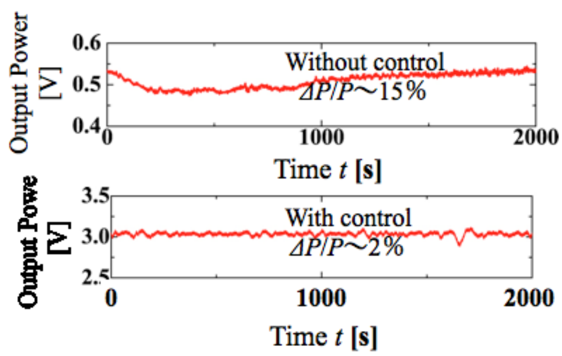


Fig. 6. The time evolutions of gyrotron output power.

4. Conclusion.

The fluctuation level of output power has been reduced from 15% to 2% by the feedback control of the output power to adjust heater voltage.

References

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