§19. Development of Powerful Sub-terahertz Pulse Gyrotron

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i) Introduction

Gyrotrons are very attractive for applications in very various fields. Use in collective Thomson scattering (CTS) diagnostics of fusion plasmas is mostly fit for gyrotrons on their distinctive ability of high power at high frequencies. Gyrotrons developed for electron heating are currently used for CTS diagnostics.^{1, 2)} However, EM waves within the frequency range of these gyrotrons suffer from severe refraction and/or absorption. Strong electron cyclotron emission is a large noise source. Use of a gyrotron in a sub-THz frequency range will resolve these problems.

We have been developing high power sub-THz gyrotrons.³⁾ Recently, we have succeeded in oscillation approaching 100 kW at 389 GHz.⁴⁾ Second harmonic (SH) oscillation was used to relax the requirement for super conducting magnets. However, mode competition with fundamental harmonic (FH) modes has prevented achievement of much higher power.⁵⁾

Then, we are now developing an FH mode sub-THz gyrotron. We have reported the first result of the oscillation test of this gyrotron.^{6, 7)} The maximum power was about 190 kW. In this paper, experimental results for over 200 kW oscillation are described.

ii) Experimental results

Figure 1 shows the FH mode gyrotron. It is mounted on a liquid He-free 12 T super conducting magnet, the diameter of the room temperature bore of which is 100 mm. The electron gun was very carefully designed for realization of a high quality electron beam at large beam currents.⁷⁾ This gyrotron is equipped with an internal mode convertor for radiation of a Gaussian beam. The vacuum window is made from a single crystal sapphire disk of c-axis cut. The design oscillation mode and the frequency are co-rotating TE_{14,2} mode and 295 GHz, respectively.

Succeeding the first result, the alignment of the gyrotron was carefully adjusted with respect to the magnetic axis of the super conducting magnet with the accuracy less than 0.1 mm. The result is shown in Fig. 2. It plots window power P measured with a water load and the efficiency as functions of the beam current I_b . The value of P increases with I_b and attains to almost 220 kW at I_b of 14 A. The efficiency is almost constant at about 25%. These values were obtained at the beam voltage V_k of 60 kV. The design value is 65 kV. The present value is mainly limited by the power supply. We will increase the available value of V_k for higher power.

The radiation pattern was measured with an infrared



Fig. 1 Photograph of the pulse gyrotron



Fig. 2 Oscillation power and efficiency are plotted with closed circles and closed squares respectively as functions of the beam current. The two lines along each data plot represent results of calculation with a gyrotron code.

camera. It is almost Gaussian, which indicates good performance of the internal mode convertor.

The electron gun has been replaced to further improve the electron beam quality. The experiment with this electron gun will start in the next fiscal year.

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