§28. Development of Frequency Tunable Microwave Source by Quasi-Optical Gyrotron

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A conventional high frequency gyrotron is characterized by its capacity to deliver high power in submillimeter wavelength range and frequency step-tunability due to the alternation of an operating mode. On the other hand, a quasi-optical gyrotron is a high power source offering the continuous frequency tunability in the millimeter wave range. Since some applications like plasma scattering measurements need high intensity waves, both types of gyrotrons are the most promising candidates for power sources in the millimeter to submillimeter wavelength range.

The aim of the cooperative research is to develop a conventional high frequency gyrotron and a quasi-optical gyrotron and to realize power sources for plasma diagnostics and for far-infrared spectroscopy with the high performance parameters, for example, high stability of output power and frequency, amplitude and frequency modulations, high mode purity and continuous frequency tunability.

Frequency tunable gyrotrons (Gyrotron FU series) using superconducting magnet (B<17 T) have attained operation from 38 GHz to 889 GHz. Completely cw operation has been achieved by Gyrotron FU IV. Output power is more than 20 W at the frequency of 301 GHz on the TE_{031} resonant cavity mode [1] .

The frequency of the cw gyrotron output is modulated with the time response of up to 40 kHz by variation of the electron beam energy [2] . The peak-to-peak variation of the body potential of 120 V can produce the frequency modulation of 30 MHz. The frequency is measured by a heterodyne detection system consisting of a sweep oscillator, a frequency counter, a harmonic mixer and a modulation domain analyzer.

In order to realize the high performance gyrotron operation, we have now started to stabilize the cw output. The output power fluctuates up to 5% with time. The fluctuation is mainly attributed to instability of the cathode voltage. Stabilization of the cathode voltage is essential to stabilize the output power. Higher stability can be attained by a feedback control of the output power.

According to theory, the gyrotron output power depends on the component of the electron velocity perpendicular to the magnetic field. The output power is controllable because this velocity component depends on the anode potential. Amplitude modulation of the gyrotron output is attained by utilizing such characteristics [3] .

Figure 1 shows the output power as a function of the anode potential. This dependence is promising for the feedback control because it is smooth and has a wide linear part. In order to demonstrate the possibilities of the output power control, we have examined the amplitude modulation of the output (Fig.2).

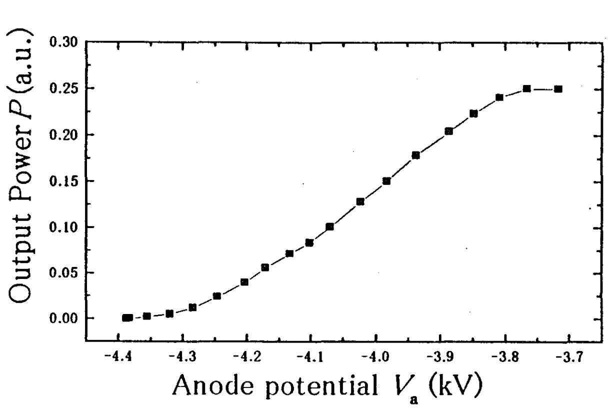

Fig.1 Gyrotron output power versus anode potential.

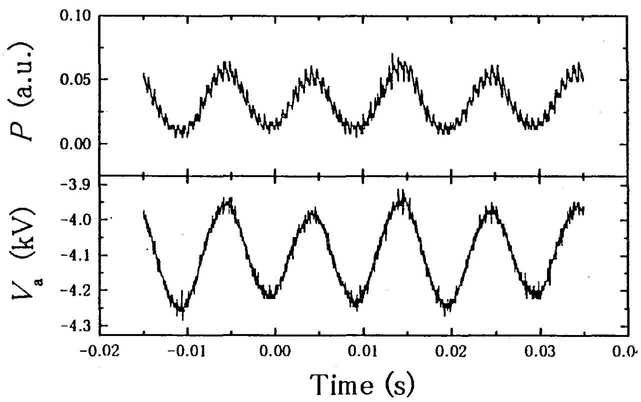

Fig.2 Amplitude modulation of gyrotron output.

References
1) Idehara, T. et al.: Int. J. Infrared and Millimeter Waves **19**, (1998) 793
2) Idehara, T. et al.: Phys. Rev. Lett. **81**, (1998) 1973
3) Idehara, T. et al.: Phys. Plasmas **1**, (1994) 461