§4. Development and Application of High Performance THz Gyrotron

Saito, T., Idehata, T., Ogawa, I., Mitsudo, S., Agusu, L. (Univ. Fukui, FIR FU),
Tatematsu, Y. (Univ. Tsukuba, PRC, Univ. Fukui, FIR FU),
Kamada, M. (JAEA),
Kubo, S., Shimozuma, T., Notake, T.,
Ando, A. (Tohoku Univ., Eng.),
Sato, N. (Tohoku Univ, RIEC)

I. Objectives

The Research Center for Development of Far-Infrared Region, University of Fukui (FIR FU) has been developing high frequency gyrotrons. FIR FU has had the world record of the highest gyrotron frequency of 889 GHz and very recently realized gyrotron oscillation at a frequency exceeding 1 THz. Moreover, gyrotron oscillation in a wide frequency range over hundreds of GHz has been shown in FIR FU. NIFS has high level technologies such as analysis of gyrotron oscillation, high quality power transmission, etc. The main objective of this study is further improvement of development of high frequency gyrotrons by combining these knowledge and technology. In addition, we have aimed at study for application of a power source in a THz range including a peniotron

II. Method and procedure

The following process was determined through discussion by the research members. First, experiments and analyses on oscillation, stability of power and frequency of FU series gyrotrons were made by the team of FIR FU. Second, this result was examined by the members of NIFS and other university. Then, emphasis was put on analysis of the oscillation characteristics of FU CW I. In particular, measurement of the radiation pattern with an infrared camera was set to be the first priority. FU CW I is a completely CW 300 GHz gyrotron. It was developed for a material processing system. FU CW I can be also used for a power source in ESR experiments or in the study of new medical processing technology. Its oscillation mode is the $TE_{22,8}$ mode. The specifications of FU CW I are given in Ref. [1].

III. Results

A plate of polyvinyl chloride was placed on the way of the output beam as a power absorber and the distribution of temperature increase was recorded with an infrared camera. This measurement was carried out in a pulse mode to avoid burning of the absorber plate. The duty factor was 5 %. A simple analysis of thermal diffusion in the polyvinyl chloride plate indicates that the measured temperature profile well reflects the power profile as long as the temperature profile is measured within a few tens of seconds.

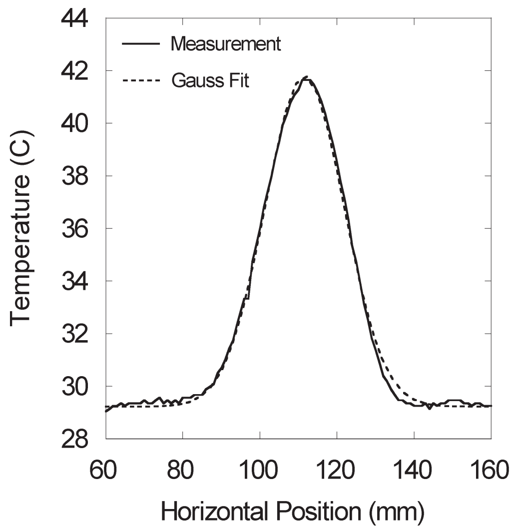

Fig.1 Distribution of temperature on the power absorber for V_C of 12 kV.

The radiation pattern showed a single peak in a range of the cathode voltage and the magnetic field strength at the cavity. Figure 1 shows an example of such a case. In this figure, is plotted the temperature distribution along the horizontal line passing the peak temperature point. It can be well fitted to a Gaussian curve. The temperature distribution along the vertical direction can also be fitted to a Gaussian but somewhat wider. In the operation condition of Fig. 1, the oscillation mode was identified as the $TE_{22,8}$ mode from a frequency measurement.

An e-folding radius w_E of the wave electric field was derived as $\sqrt{2}$ times that of the temperature distribution w_T. The same measurement was carried out at different distances from the vacuum window. Then, w_E for the horizontal and vertical directions were plotted as functions of the distance from the vacuum window. The data points closely lay on fitting curves for a Gaussian beam. Therefore, the output beam was confirmed to be a Gaussian beam. However, the radiation pattern was slightly elongated along the vertical direction.

The radiation pattern revealed a multi-peak character in the range of the cathode voltage and the magnetic field strength at the cavity. Simultaneous oscillation of multi modes was confirmed. The multi peak radiation pattern sensitively depends on the operation condition. Detailed analysis of the oscillation characteristics will guide to the way for a higher output power.

References

1. H. Hoshizuki, S. Mitsudo, T. Saji et al., Int. J. Infrared and Millimeter Waves, Vol.26, pp. 1531-1541, (2005).
2. T. Saito, T. Idehara, S. Mitsudo et al., Conf. Digest of 31st IRMMW & 14th THz (2006) p.24.
3. T. Saito, T. Nakano, K. Sakai et al., Proceedings of Eighth IEEE International Vacuum Electronics Conference (2007), pp.345-346.