300GHz 帯の高出力パルスジャイロトロンの開発
Development of a High-Power 300 GHz Pulsed Gyrotron

池内真司, 山口裕資, 笠純, 小寺政輝, 斉藤輝雄, 立松芳典, 小川勇, 出原敏孝
S. Ikeuchi, Y. Yamaguchi, J. Kasa, M. Kotera, T. Saito, Y. Tatematsu, I. Ogawa and T. Idehara

福井大学　遠赤外領域開発研究センター
Research Center for Development of Far-Infrared Region, University of Fukui

We are developing a high power gyrotron in the sub THz band for use in the measurement of collective Thomson scattering in Large Helical Device. Following realization of new power records at second harmonic oscillation [1, 2], a 300 GHz band gyrotron with the fundamental harmonic oscillation is under development aiming at more than 200 kW and a pulse-duration of ~ 1 msec. The oscillation mode was carefully chosen. A new electron gun was also designed to produce a high quality laminar electron beam in a very high magnetic field [3].

A cryogen-free 12 T superconducting (SC) magnet was introduced, and a cavity mode of $TE_{14,2}$ was selected for a fundamental harmonic frequency of 295 GHz. Over 200 kW oscillation is expected for the beam voltage V_k of 65 kV and the beam current I_b of 10 A. In the last annual meeting, we reported 175 kW as the maximum power at V_k = 60 kV and I_b = 14 A. This efficiency was 21 %. Over 200 kW oscillation was not obtained because of low oscillation efficiency.

Efforts for efficiency improvement have since been made and stable oscillation [4, 5] and precise alignment between the gyrotron and the SC magnet. Then, higher power was realized. Figure 1 plots the output power and efficiency as functions of I_b. The maximum power has attained at 234 kW at V_k = 65 kV and I_b = 11 A. The efficiency is higher than 30 % [4, 5].

Precise frequency measurement was done with a heterodyne receiver system. The measured frequency of the $TE_{14,2}$ was 293.98 GHz. The 3 dB frequency width was about 3 MHz. The measured frequency was lower than the resonance frequency of the $TE_{14,2}$ mode 294.95 GHz by 1.0 GHz. This difference corresponds to a fabrication error in the cavity radius of about 11 μm. The $TE_{14,2}$ mode is converted to a Gaussian beam by an internal mode convertor. The radiation pattern was measured with an infrared camera. The measured pattern was almost Gaussian and well reproduced the calculated radiation pattern.

In addition, we tried to expand the pulse duration. In the last annual meeting, we reported a longest pulse duration T of 20 μs for a power level of 110 kW. Now, we have succeeded in longer pulse oscillation up to 30 μs for 130 kW (Fig. 2). The red line in Fig. 2 is pyro electric detector signal. The pulse duration is mainly restricted by high voltage breakdown around the Magnetron-Injection Gun (MIG). It is planned to employ oil-insulation in the MIG region.

[1] T. Notake *et al*., Phys. Rev. Lett. **103**, 225002 (2009).
[2] T. Saito *et al*., Phys. Plasmas **19**, 063106 (2012).
[3] Y. Yamaguchi *et al*., Phys. Plasmas **19**, 113113 (2012).
[4] T. Saito *et al*., IRMMW-THz 2013, Mo5-3.
[5] Y. Yamaguchi *et al*., to be published in Plasmas Fusion Res.

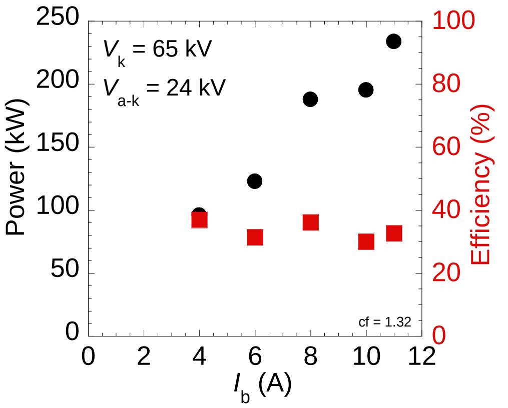

Fig1. Beam current dependence of output power and efficiency.

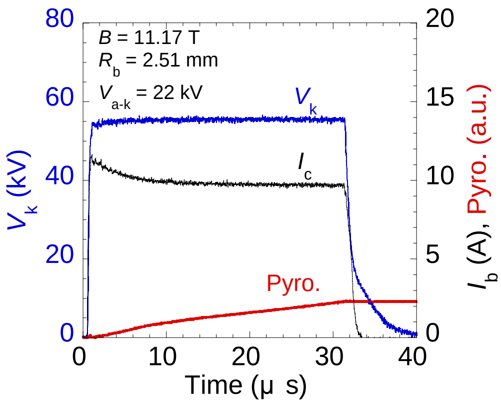

Fig. 2. Waveforms for the long pulse oscillation.