High-Power THz Radiation on a Low-Voltage 2^{nd}-Harmonic Gyrotron

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This paper presents a preliminary theoretical investigation of the low-voltage 2^{nd}-harmonic $TE_{43}^{(2)}$ mode gyrotron. It is predicted to achieve output power up to 124W on 330GHz by using an electron beam of voltage 15kV and current 0.1A. It is promising to be applied in 500MHz dynamic nuclear polarization enhanced nuclear magnetic resonance (E. A. Nanni *et al.*, *IEEE Trans. Terahz Sci Tech.*, **1**, 2011, pp. 145-163).

Gyrotrons are efficient in radiating high-frequency high-power coherent EM wave (K. R. Chu, *Rev. Mod. Phys.*, **76**, 2004, pp. 489-540). In THz band, the gyrotron development is restricted by the huge volume requirement of high voltage and high magnetic field. To develop mini THz gyrotron, it is necessary to overcome the dependence on high voltage and high magnetic field by applying low-voltage and high-harmonic operation. Due to the facts that the low-voltage operation may result in weak electron beam bunch and the high-harmonic operation may result in weak beam-wave coupling, the mini gyrotron is especially difficult to achieve high power. In this paper, the low-voltage 330GHz 2^{nd}-harmonic $TE_{43}^{(2)}$ mode gyrotron is optimized by the frequency-domain nonlinear theory to achieve relatively high efficiency.

The structure of the optimized gyrotron is shown in Fig. 1. The electron beam parameters include voltage 15kV, current 0.1A, pitch factor 1.5, and velocity spread 0.05. For the optimized structure, the efficiency is shown in Fig. 2 that the output efficiency reaches 8.26%, which indicates that the output power is up to 124W. The performance sensitivity to effective interaction length and magnetic field are respectively shown in Fig. 3 and Fig. 4. The electron beam efficiency, output efficiency, and frequency are indicated by red, blue, and green lines, respectively. The optimized parameters to achieve the highest output efficiency are marked by solid dots under L_0 =3cm and B_0 =6.05T. Extended investigation shows that the $TE_{51}^{(1)}$ mode is the potential competing mode to the desired $TE_{43}^{(2)}$ mode. The mode competition will be studied in more detail in the future.

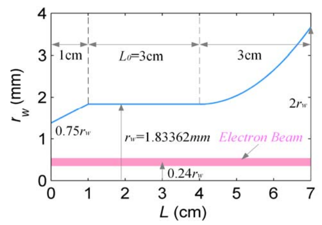

Fig. 1. Structure of the optimized gyrotron

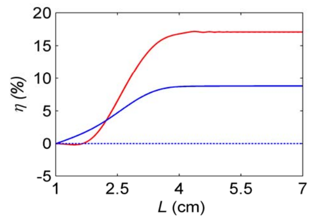

Fig. 2. Output power of the optimized gyrotron

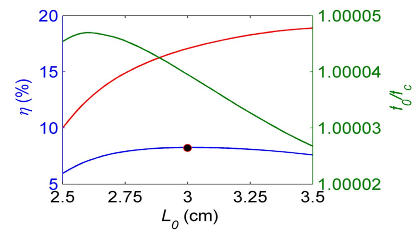

Fig. 3. Performance sensitivity to effective interaction length

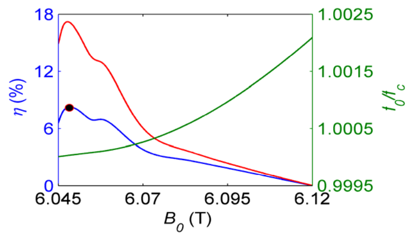

Fig. 4. Performance sensitivity to magnetic field

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