Cold Cavity Analysis for 35 GHz Gyrotron Interaction Cavity Using Free Space Method

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Abstract: *The interaction cavity simulated, designed and fabricated for the 35 GHz gyrotron is verified experimentally. Free space method for the Q value and resonant frequency measurement is used in the experiments. The WR22 waveguide based antenna system, Agilent Vector Network Analyzer are used as the experimental set-up in the cavity measurement. The simulation results for the same cavity are also obtained by using the electromagnetic simulator MAGIC for the comparison.*

Keywords: Gyrotron, Interaction cavity**,** Free space method, gyro-device.

1. Introduction

The gyrotron is a microwave vacuum device, capable to generate hundreds of kilowatt of electromagnetic power in the millimeter and submillimeter wave spectrum. The device is based on the Cyclotron Resonance Maser (CRM) instability occurring during the interaction of helically moving electrons and RF [1]. The gyrotrons are widely used as the source of high power millimeter/sub-millimeter wave radiation in the Electron Cyclotron Resonance Heating (ECRH) in plasma fusion, THz spectroscopy, heat treatment of the ceramic materials etc [2]. The millimeter wave heating shows several advantages over microwave heating, described in detail elsewhere [3]. For the material processing applications, the gyrotrons between the frequencies from 24 GHz to 35 GHz are widely used [4]. In this paper, the cold cavity measurements for the interaction cavity used in the gyrotron developed for material processing application, is performed. The geometrical parameters of the designed interaction cavity are summarized in the table 1. The destructive and non-destructive, both types of methods can be used for the *Q* measurements [5]. The non-destructive approach is used for the 35 GHz cavity measurements.

2. Experimental Arrangement

For the *Q* measurement, antenna based free space measurement set-up is used. The Agilent Vector Network Analyzer (VNA) is used as a RF source and receiver of 35 GHz frequency. WR22 rectangular waveguide based two antennas (one as a transmitter and other as a receiver) are used in the experiment. The schematic view is shown in Fig1. The interaction cavity consist three parts, the input taper, the middle section and the output taper. The transmitted signal falls on the output taper section of the cavity, as shown in fig 1. Some power enters into the cavity and some reflected back and received by the receiver antenna.

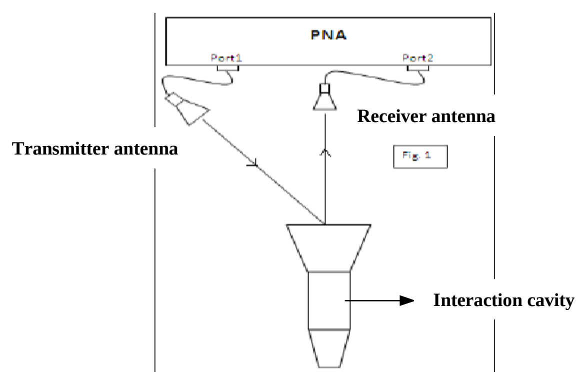

Fig. 1: The schematic view of the experimental arrangement.

Table 1: The interaction cavity geometrical parameters

Middle section length	44mm
Input taper length	30mm
Output taper length	52mm
Input taper angle	3.5°
Output taper angle	3.5°

3. Results and Discussion

The experiments for the resonant frequency and the Q value are performed between the frequencies range from 34 GHz to 36 GHz. Fig 2 shows the resonance curve for the interaction cavity. 3*dB* method is used for the Q value calculations. The obtained experimental results are verified with the simulated results. Particle-in-Cell electromagnetic simulator MAGIC is used for the resonant frequency simulations. Fig. 3 shows the simulated frequency spectrum curve for the designed interaction cavity. The experimental and simulated results are summarized in the table 2. The experimental and simulations results show very good argument.

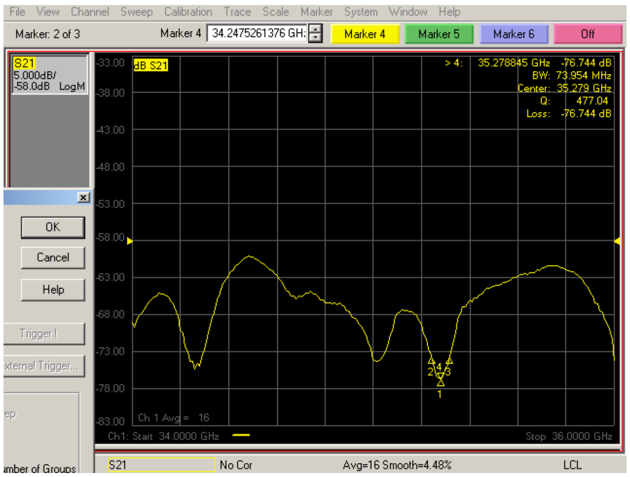

Fig. 2: S21 result for the 35 GHz interaction cavity at VNA screen.

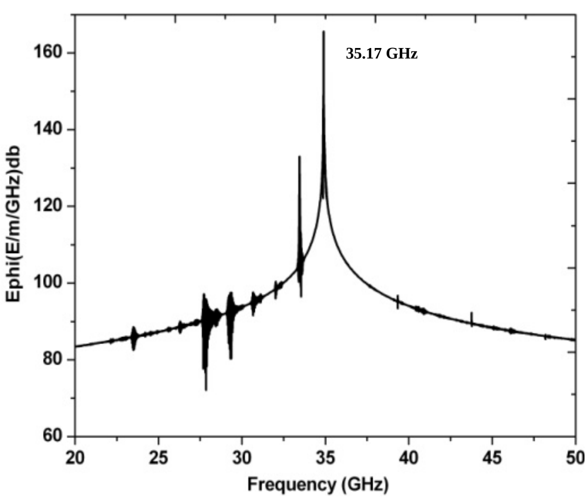

Fig. 3: The frequency spectrum obtained by the MAGIC simulation.

Table 2: Theoretical and experimental results of Q value and resonant frequency.

	Theoretical results	Experimental results
Q value	480	505
Resonant frequency (f_r)	35.17 GHz	34.95 GHz

4. Conclusion

In this paper, the experimental study of the interaction cavity for 35 GHz gyrotron has been presented. The simulation and the experimental results show the resonant frequency around 35 GHz and *Q* value around 500 (see table 2). The experimental results also verify the closeness between the simulated interaction cavity structure and fabricated cavity. Finally, the experimental results of the interaction cavity confirm the designed cavity structure.

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