A wide-band HE_{11} mode window for millimeter wave gyro-TWAs

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***Abstract*—Broadband windows are critical components in gyro-TWAs and pose a great challenge to manufacture. They are required to have very low reflection whilst coupling in microwave power. Presented in this paper is the design, simulation and measurement of a wide-band (90 to 100 GHz) multilayer microwave window using the HE_{11} mode as the input microwave mode. The simulated performance shows a better than -30 dB reflection over a 10% bandwidth of 90-100 GHz. The measured window is in very good agreement with simulations.**

I. INTRODUCTION

The gyro-devices [1-3] are high power coherent microwave sources that excel at high frequencies (up to terahertz range). Gyro-amplifiers based on the helically corrugated waveguide are able to achieve high power amplification over a large broadband range. They operate in a vacuum, usually ultra-high vacuum (UHV), to facilitate the transport of the electron beam. The microwave window acts to separate the high vacuum inside the device from the atmospheric pressure outside, whilst coupling in, or out, the microwave power.

There are many different types of microwave window such as the single-disc [4], multi-disc [5,6], pillbox and Brewster [7]. The single-disc window shows excellent microwave transmission at a singular frequency point but the bandwidth is very limited. The other three window choices can have broadband performance. The Brewster window operates with a plane-wave input but this application has a circularly polarized microwave. This paper considers the design, simulation and measurement of a multi-disc window.

Broadband microwave windows, in the form of a multilayer design are studied for application in a W-band gyro-TWA. This type of window uses different layers of dielectric material in order to provide a wider pass band than that of a single layer window. This type of window has previously been shown to have excellent broadband performance [5].

The microwave window studied in this paper is for application in a W-band gyro-TWA based on a helically corrugated waveguide [8,9] and cusp electron gun [10,11]. This device is driven by a 40 kV, 1.5 A annular axis-encircling electron beam. A gyro-TWA is currently being investigated at the University of Strathclyde. It is designed to operate between 90 and 100 GHz with an output power of 5 kW. A corrugated horn will convert the output of the interaction region, the TE_{11} mode, to the hybrid HE_{11} mode [12].

II. SIMULATION

The multilayer window is simulated using the mode-matching method. This is able to perform quick and accurate calculations of the microwave properties of a signal traveling through the window. The geometry of such a window is a central dielectric disc with a matching dielectric disc at each side separated by a vacuum gap. The schematic of the window setup is shown in Fig. 1.

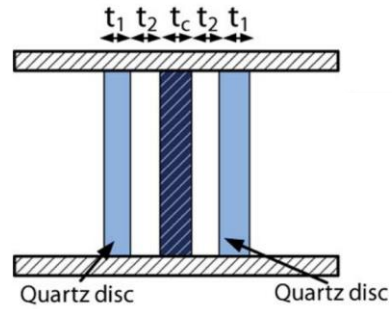


Fig. 1. Schematic of the multilayer window.

In this study the central disc is 99.7% pure Alumina (Al_2O_3) which has a relative dielectric constant of 9.75. There are many options for the matching dielectric disc material. In gyro-devices a thermionic cathode is the common choice for the electron beam source. Therefore, in this case, a material compatible with thermionic cathodes and which also gives the highest bandwidth performance was chosen. The matching discs used that meet these requirements are Quartz discs which have a relative dielectric constant 3.75. The purpose of the discs is to create additional resonant passbands on the higher and lower frequency side of the passband generated by the central disc. The comparison between the single-disc and multi-disc reflection properties can be seen in Fig. 2.

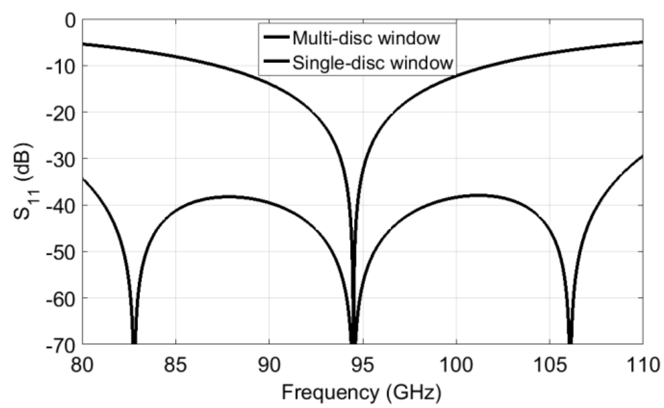
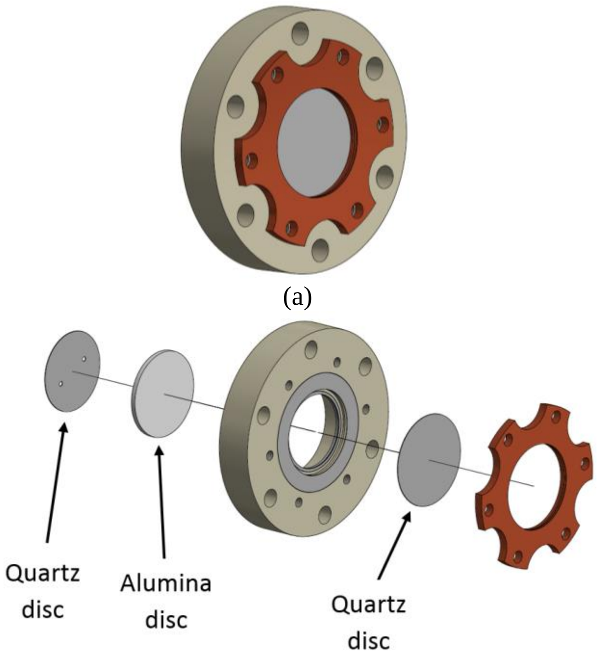


Fig. 2, Simulated reflection of a single-disc and multi-disc microwave window.

III. CONSTRUCTION AND MEASUREMENT

Optimization's of the dielectric discs thickness's and also vacuum gap spacing's show that a reflection of better than -30 dB is achievable over the 10% bandwidth.

The microwave window will have to be fitted onto the gyro-TWA assembly and also seal the vacuum of the beamtube. Therefore, the window was made compatible with a conflat flange so that it can be connected to the matching conflat flange of the gyro-TWA. The 3D drawing of the window can be seen in Fig. 3. The measurement of the wave reflection from the window is performed using a Vector Network Analyser (VNA) and is recorded.



(b)

Fig. 3. Technical drawing of the multilayer window and Conflat flange showing (a) the assembled window and (b) the exploded view of the window assembly.

IV. Summary

This paper presents the design, simulation and measurement of a multilayer window for application in a wide-band gyro-TWA. The window was designed and simulated using the mode-matching method. The simulation of the window shows a better than -30 dB reflection over 90-100 GHz. The window was measured using a vector network analyzer and the measurement is in good agreement with the simulated result.

V. Acknowledgements

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