

A microwave window for high power TWTs

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Abstract—This paper describes the development of a microwave window for high power pulsed traveling-wave tubes for radar application. Given the operational frequency band, the window dielectric materials (beryllia or alumina), and the standard waveguide (WR-90), a tridimensional frequency domain solver was used to design the window geometry. We present here the effect of the window parameters and the experimental result of a preliminary built window. The agreement between simulated and experimental results was about 97% at the beginning of the band and 92% at the end.

Keywords: microwave window; traveling-wave tube;

I. INTRODUCTION

Vacuum electron devices like traveling-wave tubes (TWTs) and klystron amplifiers need hermetic sealing to keep the internal pressure in ultra-high vacuum standards [1][3]. However, the microwave signal has to be taken in and out of the tube. Depending on the power level, the input and output coupling for the microwave signal are the microwave windows, which make the sealing in the input and output waveguides while permit the passage of microwave signal with tolerable mismatching. The dielectric materials are usually glasses or ceramics, which always cause some amount of impedance mismatching at the transition point [4][5]. In order to mitigate this problem, reactive components are added to the window by means of a thin metallic structure that we will name “mask” over the dielectric material.

In this work we present a study of the variation of three key parameters of the window mask and their influence on the impedance mismatching at the window position. Additionally, a microwave window for a WR -90 wave guide transition was built and tested experimentally.

The paper is organized as follows. In the next section we talk about the simulation and the window parameter variation study. In section III, we describe the experimental characterization of the window built. The conclusion is given in section IV.

II. MICROWAVE WINDOW PARAMETERS STUDY

Figure 1 shows the geometry simulated via a 3D frequency domain solver and the parameters under study. Given the geometry symmetry, only a quarter of the geometry was simulated, thanks to symmetric boundary conditions. The square aperture in the metallic mask has three main parameters: its height (h), its width (w), and its deepness (d) from the WR -90 flange surface. We found the minimum VSWR profile from

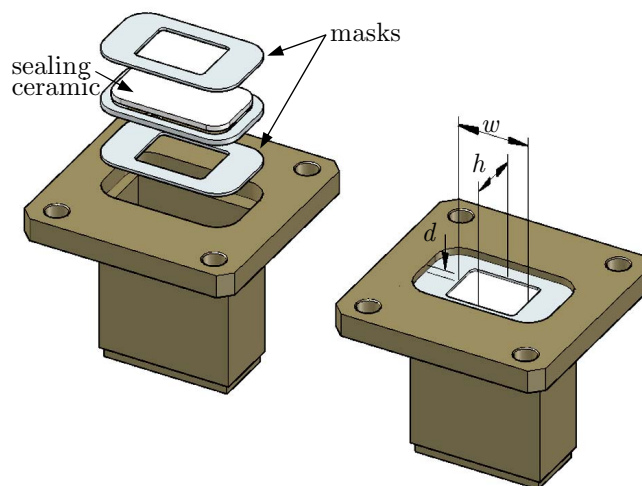


Figure 1 - Microwave window designed for a WR-90 waveguide transition flange.

8.5 to 9.5 GHz and, then verified the effect of a variation of $\pm 5\%$ in each parameter.

Figure 2 presents the simulated VSWR for a beryllia window with the following optimum combination of parameters: $h = 10.16$ mm, $w = 13.75$ mm, and $d = 1.468$ mm. The variation of $\pm 5\%$ in each parameter is also shown. One can see that the most impacting parameter is the aperture width. The aperture height is the second most impacting parameter. In this case, the optimum value is the waveguide height and, hence, no increase on this parameter was simulated. The window deepness has little influence on the VSWR profile.

III. EXPERIMENTAL WORK

The experimental setup was composed by a vector network analyzer Agilent PNA N5230A, an X-band waveguide adapter, and a WR-90 precision matched load. The experimental procedure consists in to calibrate one port using the calibration kit standard and to put the test window between the network port and the WR-90 matched load. The VSWR can be directly read from the respective measure format in the network.

Concerning the material window, the primary considerations are good thermal conductivity and very low RF loss factor. Beryllia has a thermal conductivity of 50 cal/cm.s $^{\circ}\text{C}$ and a loss tangent much less than 0.001. This is compared to alumina whose thermal conductivity is 0.1 cal/cm.s $^{\circ}\text{C}$ and loss tangent is also < 0.001 . Thus, beryllia presents desirable properties for high power applications [1].

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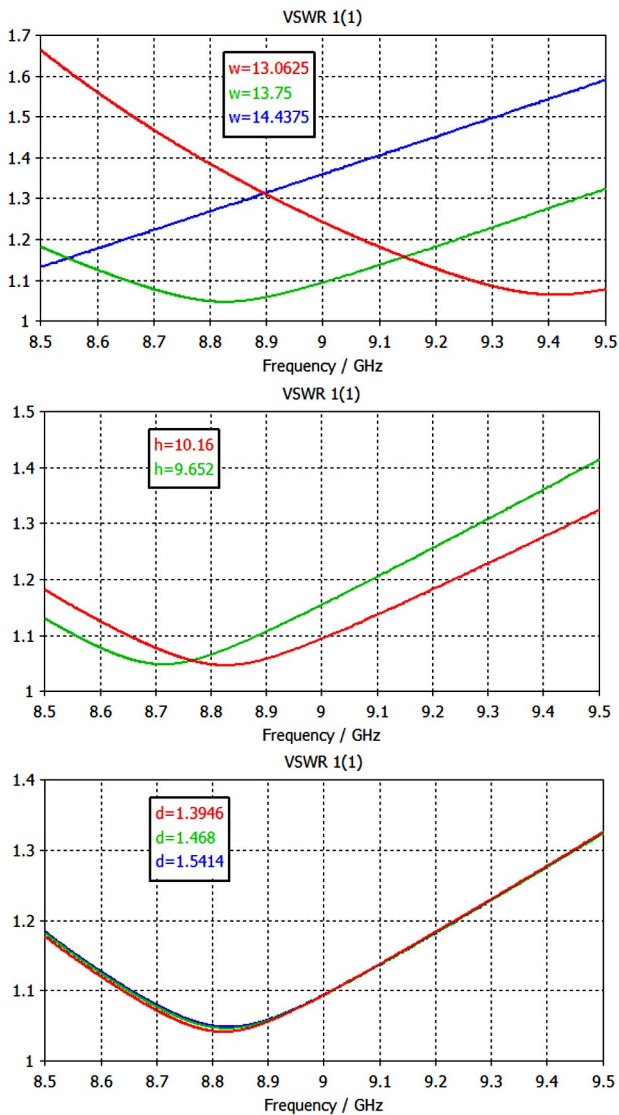


Figure 2 – Simulated VSWR for the beryllia window and a variation of $\pm 5\%$ in the three main parameters.

Given the poisoning risks of working with beryllia, we decided to verify preliminarily the agreement of the simulation with experimental results using a health risk free alumina ceramic. However, using the masks designed for the beryllia window, we could expect a serious degradation of the VSWR profile over the bandwidth of interest. Being capable of predict such degradation could be a good indication that our prediction method is reliable. This picture is illustrated by Figure 3, where we show the experimental VSWR result for the case just discussed. The experimental VSWR profile was shown to be actually lower than predicted. This was considered to be due to the poor contact between window layers (see Figure 1 left), since at this point the window is not brazed yet. Therefore, we simulated the same window with a space offset between layers of 0.1-0.3 mm, which we thought to be reasonable. We found a better agreement assuming an offset spacing of 0.3 mm between window layer. A larger

spacing could bring a better agreement, however such spacing was thought to be unlikely.

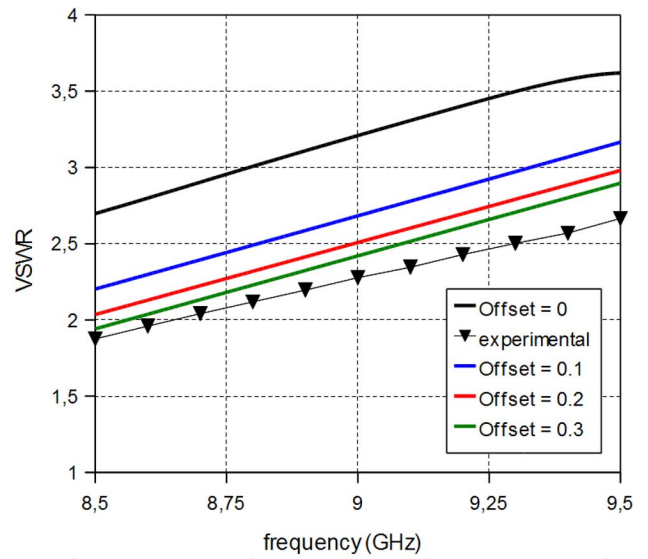


Figure 3 – Simulated versus experimental results for a alumina ceramic in window designed for beryllia. A spacing of 0.1-0.3 mm between window layers was also simulated since the experimental window was not brazed.

The disagreement between simulation with a 0.3mm offset and the experimental result is about 3% at the beginning of the band and 8% at the end. The laser cut masks matched with the manufacturing tolerances. While not brazed, the space between window layers is difficult to determine, nevertheless we can estimate it. Therefore, the disagreement observed will be subject of further investigation.



Figure 4 – Picture of the ceramic microwave under development.

Figure 4 shows the ceramic microwave window under development ready to brazing in a homemade high temperature hydrogen furnace. Fig. 5 shows the experimental set-up used to measure the microwave window impedance mismatching level and to validate the design procedure.



Figure 5 – Experimental set-up used to measure the microwave window impedance mismatching level.

IV. CONCLUSION

In this paper we described the development of a microwave window for high power TWTs with WR-90 waveguide at the input and output couplings. Using a 3D frequency domain solver, we found optimum parameters for the window masks and verified the effect of a variation of 5% in each parameter. Experimental tests with alumina indicated an agreement of 92-97% in the predicted VSWR.

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