A Pillbox Window with Impedance Matching Sections for G-band Sheet Beam TWTs

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1. Introduction

Sheet beam traveling-wave tubes (TWTs), as a kind of high-power terahertz radiation sources, have wide-spread applications in communication, security check, biomedicine, and imaging. As an important component of sheet beam TWTs, the pillbox window should ensure high vacuum environment and low transmission loss.

2. Transmission Characteristics

- The transmission characteristics of conventional pillbox windows with different dielectric materials including BeO, BN, diamond, and sapphire shown in Fig. 1(a) are studied in this paper. The relative permittivities are 6.8, 5.12, 5.68, (9.4, 9.4, 11.58), respectively and the loss tangents are 2×10^{-4}, 5×10^{-4}, 1×10^{-4}, 5×10^{-4}, respectively in the frequency of 220 GHz . The results from Fig. 2 show that the reflection coefficient S_{11} of the pillbox window with BN is larger, while the transmission coefficient S_{21} with sapphire is lower, in the frequency range of 210 ~ 230 GHz. Therefore, diamond is relatively the optimal dielectric material due to the toxicity of BeO.
- To improve the transmission characteristics of the diamond pillbox window, a modified pillbox window with additional impedance matching sections (IMS) is investigated, as shown in Fig. 1(b) . Fig. 3 shows that, in the frequency range of 212 ~ 232 GHz, the diamond pillbox window with IMS can decrease the reflection, and the voltage standing-wave ratio (VSWR) is reduced accordingly.

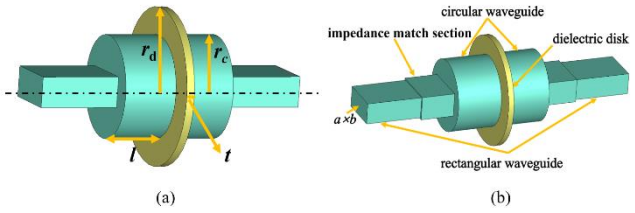

Fig. 1. The structures of the pillbox windows. (a) without and (b) with IMS.

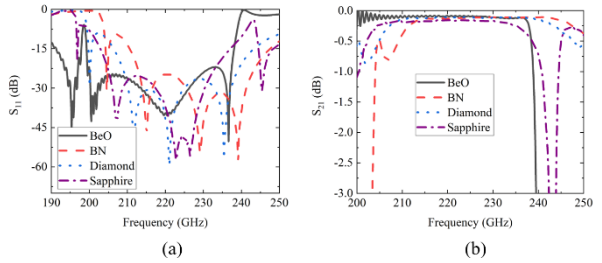

Fig. 2. Transmission characteristics of pillbox windows with different dielectric materials. (a) S_{11}; (b) S_{21}.

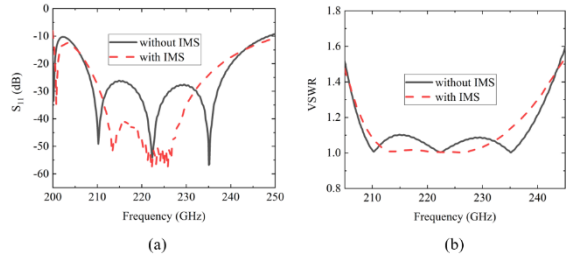

Fig. 3. Transmission characteristics of pillbox diamond windows without and with IMS.(a) S_{11}; (b) VSWR.

3. Sensitivity Analysis

- Fig. 4 shows that the S_{11} is less than -15 dB in the frequency range of 210 ~ 240 GHz when the circular waveguide radius r_c is changed by ± 0.02 mm, and the S_{11} < -15 dB maintains around the frequency range of 210 ~ 237 GHz when the circular waveguide length l is changed by ± 0.04 mm.

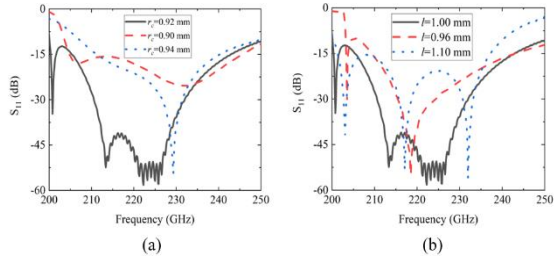

Fig. 4. Sensitivity of (a) Circular waveguide radius r_c and (b) its length l.

4. Conclusion

- In summary, the transmission characteristics of pillbox windows with different dielectric materials are studied in this paper. Through simulation analysis, the improved pillbox window with IMS provides the frequency range of 212 ~ 232 GHz (20 GHz) for S_{11}< -30 dB. The sensitivity of the circular waveguide structure parameters on the reflection coefficient is studied. It can meet the requirement of energy transmission in 220 GHz sheet beam TWT.

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