42:Design of Dielectric Loaded Sheet Beam Klystron Cavity

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Abstract: *This paper gives a new design for the cavity of Sheet beam Klystron (SBK) which has lot of advantages as well as some design challenges. This cavity design employs dielectric loading for flat field across the beam.*

Keywords: Sheet beam; klystron cavity; dielectric loading; rectangular re-entrant cavity;

Introduction:

Several attempts are consistently made in vacuum electron devices to penetrate still deeper into the higher frequency regime and in parallel there is a constant progress in the state of art in the lower frequency regime. SBK is one such device which is expected to give better performance in both high and low frequency regimes. Since the beam area is increased, the beam current density is decreased and hence the space charge forces are minimised. Thus the large lateral beam dimensions permit high power to be attained with low current densities in the cathode, and low power concentration in the cavities.This decreased current density leads to use of low Brillouin magnetic field such that one can employ simple permanent magnets instead of going for solenoids with separate power supply as used in conventional cylindrical beam klystrons. Besides these advantages there are several critical issues in this devices such as high aspect ratio sheet electron beam generation and need for design with high transmission efficiency. Also because of diocotron effect the breakdown of the beam might occur. In addition, the drift tube can propagate all the TE modes and hence there is a serious problem of feedback and oscillations. Since the Sheet beam structure is azimuthally asymmetric, only 3D-simulation codes have to be used.

Major Challenges:

Due to the large lateral dimension of the beam, SBK requires large drift tubes and over moded cavities. Major objectives in the cavity design of sheet beam tubes are a flat field across the whole beam width, a large (unloaded) shunt impedance and reduction of transit time effect. Also attempts have been to increase R/Q for enhancement of coupling coefficient.

Dielectric Loaded Cavity Design:

A new design approach for the SBK cavity has been attempted in this paper. For good transmission efficiency of the electron beam overall cross section of the beam should be subjected to uniform electric field. To attain this uniform field across the cavity over the broad dimension of the cavity, barbell cavity [1] is used till now. This employs quarter wave section on either side to confine the energy within the required region.

When simulating simple rectangular version of the conventional klystron, we got Gaussian shaped field, which is undesirable. So we employed two thin dielectric sheets on either side near the gap to get uniform field. Although a similar idea was previously proposed [2], till now no such SBK cavity design has been reported. Fig 1a shows the cavity designed with dielectric loading for X-band (11.4 GHz). The cavity is operated in the dominant mode unlike barbell cavity which is operated in the higher order mode. There is only a small reduction in cavity dimensions for this frequency band compared to the barbell cavity design.

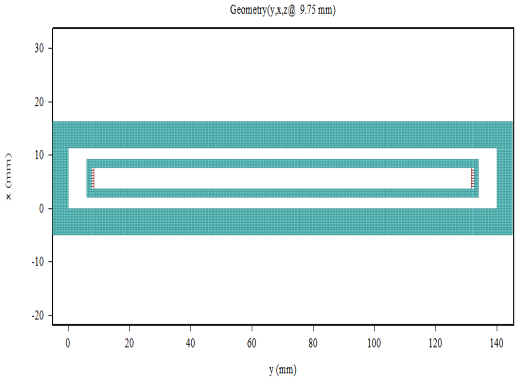

Figure 1a. XY plane view of the cavity loaded with dielectric APBN (ε_r=4.2)

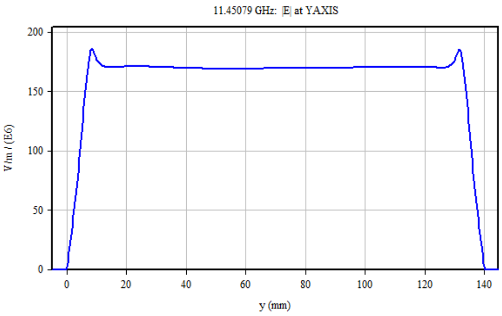

Figure 1b. Electric Field profile across the overall width of the cavity shown in figure 1a

Fig 1b. shows the obtained field profile across the broader dimension of the cavity using MAGIC 3D simulation. From Fig 1a we can see that beam of width around 11cm can be used without any difficulty. The initial estimation of important parameters of the cavity such as Q, R/Q has been done using 3D codes. There is about 20-50% increase in the R/Q value using this design compared to conventional barbell cavity [3]. The design is being optimized for the better results.

A variant of the above cavity was also attempted, to remove the peaks on either side of the field profile. Fig 2a shows its structure and fig 2b shows the corresponding field profile, which is devoid of peaks in fig 1b. Even the R/Q of both the types does not differing much.

The thickness of the dielectric sheet and its dielectric constant determine the field profile. The Eigenmode frequency, Q and R/Q dependence on the dielectric thickness is not appreciable.

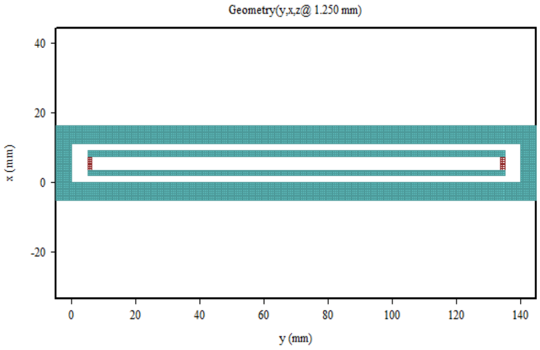

Figure 2a. XY plane view of the cavity loaded with dielectric APBN (ε_r=4.2) without drift tube narrow walls

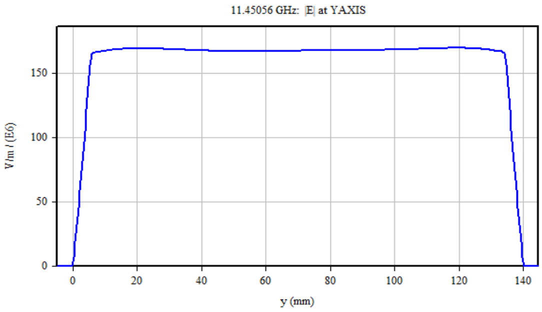

Figure 2b. Field profile across the overall width of the cavity shown in figure 2a

Conclusion:

The RF cavity for a sheet beam klystron has been designed using CST Microwave Studio and MAGIC codes. The results of two codes have been compared for design validation. Dielectric loading is proposed for getting flat field across the beam.

Acknowledgement:

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