LTCC Partially-Filled Oversized Rectangular Waveguide-Fed Slot Array in the Millimeter-Wave Band

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1. Introduction

In this paper, an air-cavity is introduced in the radiating oversized waveguide of LTCC (Low Temperature Co-fired Ceramics) to reduce the dielectric loss and increase the efficiency. The air-cavity reduces the equivalent dielectric constant and enhances the bandwidth of the series-fed slot array antenna [1]. The main beam tilting angles of three kinds of the partially-filled antennas have been measured and compare to those of the fully-filled antennas.

2. Estimation in the partially-filled oversized rectangular waveguide-fed slot array

An LTCC partially-filled oversized-rectangular waveguide slot array antenna is shown in Fig.1. The antenna consists of a single mode waveguide feed and an oversized-rectangular waveguide orthogonally arranged on the common layer [2]. A traveling quasi-TEM wave couples to the free space through a slot array on the board wall of the oversized waveguide. The lower dielectric constant will suppress the long line effect. The dielectrics at the narrow walls will realize quasi hard-walls to enhance the field uniformity in the transverse direction.

Fig.2 shows the estimated transmission loss and effective permittivity for different filling rates at 60GHz assuming the loss tangent is 0.013 and the total thickness is 0.8mm. For a half -filled oversized rectangular waveguide (2h=0.4mm) the effective dielectric constant can be reduced to 30% and 90% of dielectric loss can be reduced.

The main beam tilting angles of three kinds of partially- filled antennas summarized in Table 1 have been obtained by near field measurement. Two different sizes of fully-filled antennas have also been measured as a comparison. Fig.3 shows the frequency characteristics of the main beam tilting angle θ in the E-plane which has been normalized at 58.5GHz. In the figure, "35mm" and "45mm" mean the sizes of the air cavity. The slope of the angle gives the beam tilting characteristics in terms of frequency. Thereby smaller dielectric constants in propagation for the partially-filled antenna suppress the long line effect and the slope of tilting angle is smaller than the filly-filled antennas.

3. Conclusion

In summary, an LTCC partially-filled slot array antenna is introduced in the radiating oversized waveguide to reduce the dielectric loss and increase the efficiency. It is possible to get the bandwidth enhancement due to the reduced long line effect. This work is financially supported by the national federation of small business associations in part.

References

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[2] J.Hirokawa et al., IEEE Trans. Antennas & Propagat., vol.46, no.5, pp.625-630, May 1998.

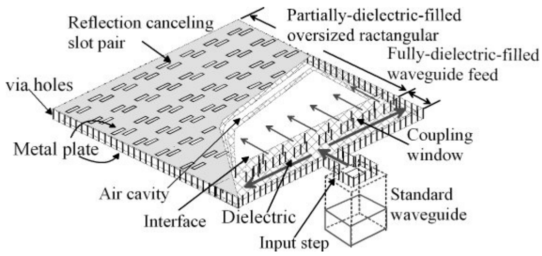

Fig.1 Full-filled waveguide feed for a partially-filled oversized-rectangular waveguide slot array antenna

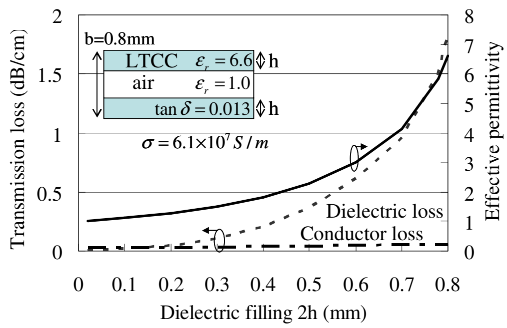

Fig.2 Estimated transmission loss as a function of dielectric filling in a parallel-plates at 60GHz

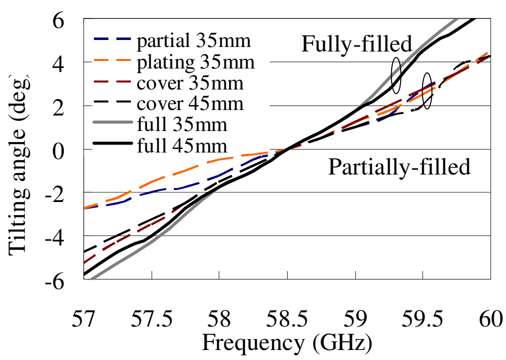

Fig 3 Frequency characteristic of the tilting angle

Table 1 Types of fabricated waveguides

Partially-filled		Fully-filled
0.2mm LTCC / 0.4mm air ε r=1 / 0.2mm LTCC silver coating: **partial** copper coating: **plating**	0.2mm LTCC / 0.2mm / 0.4mm / 0.2mm / 0.2mm LTCC LTCC cover: **cover**	0.8mm LTCC ε r=6.6 Fully-LTCC-filled: **full**