SESSION 22: DIELECTRIC WAVEGUIDES

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In the conventional microwave range of centimeter wavelengths, the transmission of energy with the lowest amount of attenuation is achieved by using hollow metal waveguides. At much higher end of the electromagnetic spectrum, at optical frequencies, the lowest attenuation is achieved by using the dielectric fibers. At millimeter wavelengths, both metal and dielectric waveguides can be used. Nevertheless, much of the research effort in this area is presently concentrated on the dielectric waveguides.

The use of dielectric waveguides is dictated by the fundamental properties of available materials. Wang and Schwarz [1] have estimated the crossover frequency, at which the waveguides with metal conductors have about the same attenuation as waveguides composed entirely of dielectrics, to be about 67 GHz. Although the transition is very gradual, so that the estimate may be easily shifted by a factor of two in either direction, it is safe to predict that the microwave circuit elements at frequencies above 60 GHz will largely use the dielectric waveguide technique in order to minimize the dissipation.

If the low dissipation was the only consideration, one would encounter nothing but metal waveguides in microwave components operating below, say, 30 GHz. As it is well known this is not the case, because the requirement for low cost has greatly increased the use of dielectric materials even there. The low cost is closely related to the ease of fabrication. The wave-guiding structures consisting of metal conductors on planar dielectric sheets, such as microstrip or fin-line, are making the integration of various circuit elements extremely simple. As a consequence, the fabrication cost is low.

For the very same reason, most of the dielectric waveguides presently under investigation are of the planar shape. Therefore, they are classified as open guided wave structures. On such structures, the electromagnetic field solutions have the continuous-spectrum representation, which renders the exact analysis of the guided waves quite difficult. One possible theoretical treatment of such planar dielectric waveguides uses a generalized transverse-resonance method developed by Peng and Oliner [2]. Their paper provides a detailed tutorial presentation on the subject, and it also contains a review of the pertinent literature. An alternative theoretical approach is the mode matching, such as utilized by Mittra et al. [3].

The present session gives an insight into experimental efforts of developing various millimeter-wave components in dielectric-waveguide technique. The paper by Bruno and Bridges discribes the experiments of manufacturing a dielectric waveguide by pressing the high-dielectric powder into a groove made in a low-dielectric substrate. The second paper by Kim et al. describes a 3 dB coupler made of a single piece of dielectric. Their design procedure yields a constant coupling over an increased bandwidth. The paper by Mizumoto et al. describes a study of the dielectric waveguide with metal strips. The structure is intended for building nonreciprocal devices by utilizing substrate made of magnetic material. The last paper, by Malherbe et al., reports on a transition between the standard rectangular metal waveguide and a nonradiative dielectric waveguide.

References

[1] T. Wang and S.E. Schwarz, "Design of dielectric ridge waveguides for millimeter-wave integrated circuits", IEEE Trans. Microwave Theory Tech., vol. MTT-31, pp. 128-134, February 1983.

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[3] R. Mittra, Y.L. Hou, and V. Jamnejad, "Analysis of open dielectric waveguides using mode-matching technique and variational methods", IEEE Trans. Microwave theory Techn., vol. MTT-28, pp. 36-43, January 1980.

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