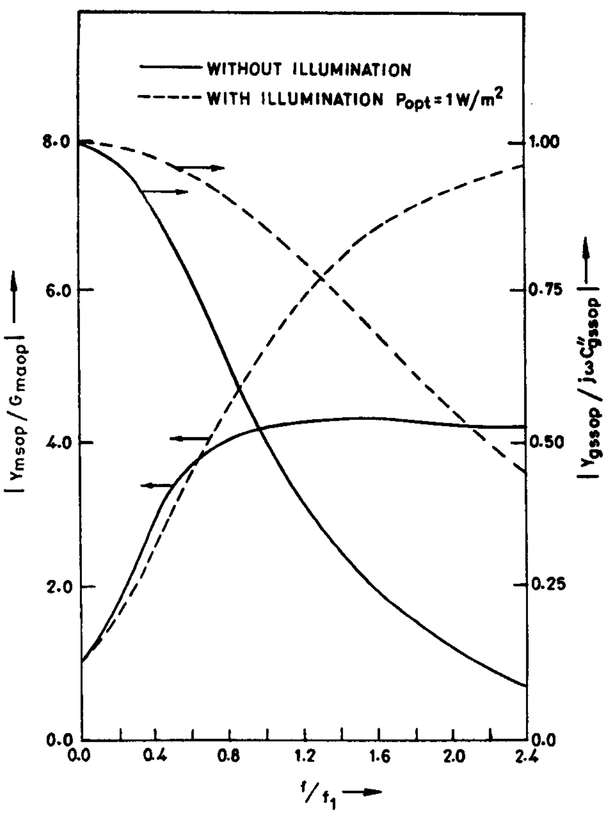

Figure 4 Variation of the magnitude of Y_{gss} and Y_{ms} with normalized frequency under dark and illuminated conditions

sponding variations in the linear region. However, the effect of illumination has been found to be more pronounced at higher values of frequencies. It can be further seen from the figure that at frequencies much lower than the cutoff frequency, the effect of illumination is much less and tends to decrease the magnitude of Y_{ms} in the illuminated condition under saturation. On the other hand, at higher frequencies, the magnitude of Y_{ms} (at a fixed frequency) increases in the illuminated condition. The effect of illumination is also more pronounced in this frequency range.

CONCLUSION

A nonquasistatic model of an optically controlled GaAs MESFET presented here can estimate the effect of illumination on the microwave characteristics of the device. It has been observed that the equivalent circuit parameters (Y parameters) and R, L, and C elements of the small-signal equivalent circuit can be precisely controlled by the incident optical power. The model can be used as a basic tool for examining the potential of the device for optical to microwave conversion and optically controlled amplification at microwave frequencies. Moreover, the model can be implemented in a circuit simulation package such as SPICE with little modification.

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RESONANT FREQUENCIES OF A MICROWAVE PACKAGE WITH VERTICAL DIAPHRAGMS ATTACHED TO THE TOP COVER

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KEY TERMS

Resonant frequencies, package with diaphragms, mode-matching method

ABSTRACT

The resonant frequencies of the modes in a cabineted microwave package are investigated by the mode-matching method. The upper region of the package is partitioned into several cabinets using vertical diaphragms of a same depth and of negligible thickness. Numerical results are shown to agree with those of the measurement. The change of the resonant frequencies with the diaphragm depth is presented and explained. It is found that the resonance-free frequency bands can be broadened by suitably designing the positions and the depth of the diaphragms. © 1995 John Wiley & Sons, Inc.

I. INTRODUCTION

In a packaged MMIC, field may be radiated from circuit elements, causing interactions between the elements and the package [1]. With increased frequency, these interactions may become uncontrollable and thus alter the electrical performance of the circuit. To isolate these high radiation elements, one of the approaches is to partition the packaged circuit into several cabinets using the metal diaphragms (Figure 1). The diaphragms can reflect the radiation field [2] and confine the field in the small cabinets.

However, if no suitable absorbing material is placed inside the cabinets, the confined field will leak out by way of the (air and substrate) region beneath the diaphragms and couple with the resonant modes of the cabineted package. This coupling becomes large when the operating frequency is near the resonant frequencies of the modes. In this article we use the mode-matching method to analyze the variation of these resonant frequencies with the change of the diaphragm depth. Numerical results of several packages are presented and explained.

II. ANALYSIS

Consider the structure shown in Figure 1, where a dielectric substrate with permittivity ϵ_r and height h is enclosed in the bottom of a metal box. $K_x - 1$ and $K_y - 1$ vertical diaphragms are used to equally divide the upper (air) region of the box into, respectively, K_x segments in the x direction and K_y segments in the y direction, so that totally $K_x \times K_y$ equal-sized cabinets are formed. The diaphragms are assumed to be of the same depth d and of negligible thickness.

The cabinets can be treated as z-directed small rectangular waveguides all short-circuited by the upper cover of the package box. The fields in each cabinet are expanded by the TM and TE (to z) modes of the waveguide. Similarly, the region beneath the diaphragms ($0 \le z \le c - d$) is a large waveguide terminated by a short-circuited dielectric-filled waveguide. The fields in this region are expressed by the TM and TE (to z) modes of the large waveguide.

At the plane of $z = c - d$, the fields of the small waveguides are enforced to equal those of the large waveguide. The resultant equations are then suitably weighted by the modal fields [3]. After eliminating the unknown coefficients associated with the expansion modes of the small waveguides, a homogeneous equation is obtained:

$$\bar{\bar{\mathbf{A}}}(f) \cdot \bar{x} = 0, \tag{1}$$

where $\bar{x}$ corresponds to the unknown modal coefficients of the large waveguide and $\bar{\bar{\mathbf{A}}}$ is a frequency-dependent matrix. By searching the zeros of the determinant of $\bar{\bar{\mathbf{A}}}$, one finally obtains the resonant frequencies of the package.

III. RESULTS

To ensure the validity of the analysis, we compare the calculated and measured frequencies of a substrate-free ($h = 0$) package. The results are shown in Figure 2. The package has a size of $a \times b \times c = 45 \times 25 \times 20$ mm^3 and is partitioned into two cabinets by a diaphragm located at $x = a/2$ (i.e., $K_x = 2$, $K_y = 1$). The diaphragm thickness is 1 mm in the

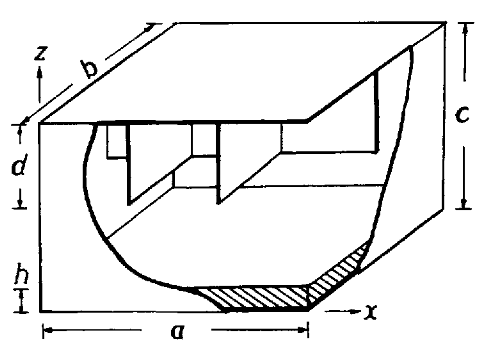

Figure 1 A microwave package with bottom substrate and upper cabinets partitioned by vertical diaphragms

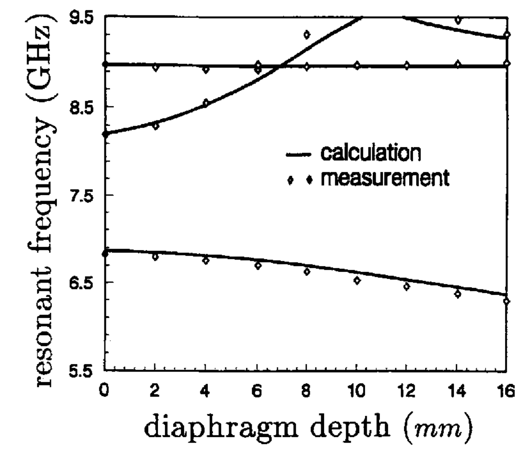

Figure 2 Comparison of the calculated and measured resonant frequencies of a substrate-free, two-cabineted package. $a \times b \times c = 45 \times 25 \times 20$ mm^3, $h = 0$. $K_x = 2$, $K_y = 1$

experiment. Good agreements can be observed between the results of the calculation and the measurement.

Figure 3 illustrates the calculated resonant frequencies, as a function of the diaphragm depth d, of a package with two cabinets ($K_x = 2$, $K_y = 1$). $a \times b \times c = 20 \times 12 \times 8$ mm^3. The thickness h and the permittivity ϵ_r of the substrate are 1 mm and $9.7\epsilon_0$, respectively. The notations of the curves represent the modes of the package without diaphragms ($d = 0$). For the package size considered, no resonant frequency is below that of the TM_{110} mode. For the $TM_{2m,n,l}$ and $TE_{2m,n,l}$ modes, the placement of the metal diaphragm at $x = a/2$ has no influence on the field distributions, because the tangential electric fields (E_y and E_z) of these modes are essentially zeros with and without the diaphragm. Thus, the calculated resonant frequencies of TM_{210} and TE_{011} are independent of the diaphragm depth. Also note that the frequencies of the first few $TM_{2m+1,n,l}$ modes ($TM_{110}, TM_{310}, TM_{120}$) decrease, while those of $TE_{2m+1,n,l}$ modes (TE_{101}) increase, with the raise of the diaphragm depth. As predicted by the perturbation theory, the resonant frequency of a cavity mode decreases (increases) when one inserts a metal conductor at the place where the electric energy of the mode is larger (smaller) than the magnetic energy [4]. A simple calculation does show that at $x = a/2$, the electric energies are larger than the magnetic energies for the TM_{110}, TM_{310}, and TM_{120} modes, and vice versa for the TE_{101} mode.

Due to these phenomena, it can be observed from Figure 3 that the frequency band between the resonant frequencies of TM_{110} and TM_{210} increase from 3.72 to 5.33 GHz when the diaphragm depth is raised from 0 to 6 mm. Also, the band between the frequencies of TM_{210} and TE_{101} grows from 1.55 GHz to a maximum of 2.90 GHz when the diaphragm depth is increased to 3.2 mm.

Figure 4 presents the resonant frequencies of a package similar to that in Figure 3. Here, an additional diaphragm is put at the plane of $y = b/2$ so that the upper region inside the package is partitioned into four cabinets ($K_x = 2$, $K_y = 2$). By the aforementioned reason, the addition of this diaphragm makes no difference on the resonant frequencies of the TE_{101} and TM_{120} modes, so, as it can be observed, the curves for these two modes are identical to those in Figure 3. However, due to the energy difference between the electric

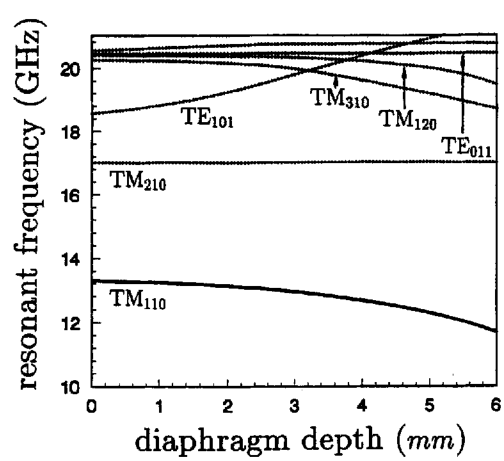

Figure 3 Resonant frequencies, as a function of the diaphragm depth, of a two-cabineted package. $a \times b \times c = 20 \times 12 \times 8$ mm^3, $h = 1$ mm, $\epsilon_r = 9.7$. $K_x = 2$, $K_y = 1$

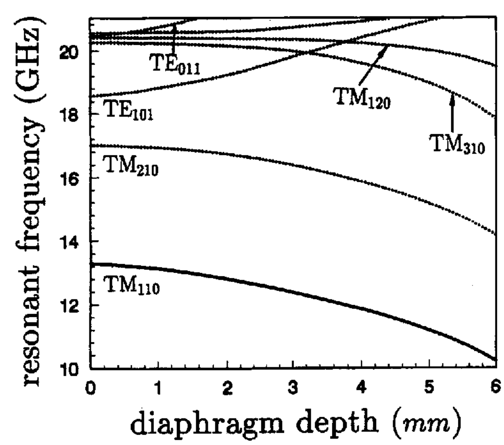

Figure 4 Resonant frequencies, as a function of the diaphragm depth, of a four-cabineted package. $a \times b \times c = 20 \times 12 \times 8$ mm^3, $h = 1$ mm, $\epsilon_r = 9.7$. $K_x = K_y = 2$

and magnetic fields at $y = b/2$, the frequencies of TM_{110}, TM_{210}, and TM_{310} are reduced and that of TE_{011} is raised when this additional diaphragm is inserted. Note that the frequency band between TM_{210} and TE_{101} is further increased to 3.61 GHz at the diaphragm depth of 3.2 mm.

IV. CONCLUSIONS

In this letter, we have analyzed the resonant frequencies of a cabineted microwave package by the mode-matching method. The validity of the analysis has been checked by comparing the results of the calculation and the measurement. It is found that the resonance-free frequency bands can be broadened by suitably designing the positions and the depth of the diaphragms.

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AN APPROACH TO FOCUSED 2D TM NEAR-FIELD ACTIVE MICROWAVE IMAGING OF DIELECTRIC OBJECTS

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KEY TERMS

Microwave imaging, inverse scattering, numerical method

ABSTRACT

A new integral-equation-based numerical approach to microwave imaging is presented. It can be applied to focused imaging in the sense that only one part of an inhomogeneous body is viewed as an unknown scatterer to be reconstructed. This approach is of great usefulness in many applications, as it results in a notable computational saving and in high flexibility. Moreover, it allows the range of applicability of the Born approximation to be considerably expanded. © 1995 John Wiley & Sons, Inc.

INTRODUCTION

Traditional approaches to the inverse scattering problem require that the whole spatial domain where scatterers may be present be regarded as an investigation domain. They consider any dielectric discontinuities in an infinite or (at least) semiinfinite homogeneous medium as objects to be detected, so the whole scene must be discretized, even when it is partially known. As the size of the investigation domain increases, the computation becomes very heavy and inaccurate, mainly because of poor conditioning [1]. Moreover, in many practical applications, the bodies under test differ only partially from a known standard model, so it would be useful to take into account a priori information in order to reduce the computational load.

This article presents a numerical approach to the reconstruction of the dielectric characteristics of unknown dielectric objects located inside a fixed (in general, inhomogeneous) space region. The approach is based on an integral-equation formulation of the inverse scattering problem [2]. The aim is to develop a methodology that allows the investigation domain to be restricted to a subdomain of interest inside a given scene, thus resulting in a notable computational saving. The proposed method requires two steps: the solution of a