M-4

ANALYSIS OF M.I.S. OR SCHOTTKY CONTACT COPLANAR LINES USING THE F.E.M. AND THE S.D.A.

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ABSTRACT

The finite element method and the spectral domain approach are used to optimize M.I.S. and Schottky contact coplanar waveguides because the range domain of the slow wave mode depends stronger the geometrical size.

INTRODUCTION

For analog devices the existence of propagation modes with very low phase velocity on M.I.S. and Schottky contact planar lines allows the reduction of dimensions of distributed components.

Furthermore, the propagation properties of Schottky contact lines can be modulated by D.C. bias voltage.

In fact, to be used in monolithic technology the semiconductor substrate must be multilayered one with semi insulating region under the active layer (fig.1).

Until now, results have been presented to show the validity of analysis [1,2,3,4,5] and compared with experimental results obtained by H.HASEGAWA [6].

The purpose of this paper is to study the effects of all parameters (width of the strip and of the slots, conductivity and thickness of the epitaxial layer) on the slow wave domain and on the attenuation.

I - ANALYSIS

Two analysis have been used to study the propagation in M.I.S. coplanar lines. The first one is the finite element method [1] (F.E.M.) and the other the spectral domain approach [2] (S.D.A.).

These numerical methods are commonly used to study the propagation in lossless cases but in these lines losses cannot be taken as a perturbation and analysis have been developped taking into account the conductivity of the epitaxial layer.

1. Finite element method [7]

Maxwell's equation in dissipative mediums are developped in considering E and H as vector distributions.

The F.E.M. is applied to transform the problem into a matrix system. The method consists in dividing the cross section of the waveguide into triangular subdomains. The longitudinal components E_Z and H_Z of the electromagnetic field are written as :

$$E_Z = \sum_{i=1}^{n} a_i \ \phi_i(x,y) \qquad H_Z = \sum_{i=1}^{n} b_i \ \phi_i(x,y)$$

$\phi_i(x,y)$ are functions defined on each triangular subdomain. The final matrix system is of the form :

$$A X = \lambda B X$$

where A and B are two symmetrical complex matrices and X a complex vector representing the longitudinal components of the electromagnetic field at each node of the cross section.

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For a fixed frequency, if $\gamma = \alpha + j\beta$ is the complex propagation constant, an iterative procedure on (and β is used to solve (1)

2. Spectral domain approach [2]

The field components of the hybrid guided waves are expressed in term of $\tilde{E}_Z(a,y)$ and $\tilde{H}_Z(a,y)$ the Fourier transforms with respect to x of the axial electric and magnetic field components $E_Z(x,y)$ and $H_Z(x,y)$. The boundary conditions at the different interfaces can be written as :

$$Z(a,\gamma\ ,\omega,\ \varepsilon_i) \begin{bmatrix} \tilde{J}_Z(a) \\ \tilde{J}_X(a) \end{bmatrix}_{y=D} = \begin{bmatrix} \tilde{E}_Z(a) \\ \tilde{E}_X(a) \end{bmatrix}_{y=D}$$

where D is the ordinate of the metallic strips, ε_i the real or complex relative permittivity of each medium. The solution of this set of equations is then achieved by means of Galerkin's method, in which the electrical field components in the slots are expanded in suitable series of basis functions.

II - RESULTS

Theoretical results obtained by the two numerical method are presented on fig.2 and compared with experimental results [6]. The S.D.A. is easier to set up than the F.E.M. and especially if only few basis functions are used. The increase of the number of basis functions up to 14 slightly increase the values of the slow wave factor. So, two basis functions can be used to optimize the structure. But for narrow strip it is necessary to increase the order of expansion, in order to take into account the coupling between the two slots.

Fig.3 gives an example of M.I.S. coplanar line realized on a thin epitaxial layer (0.7 µm) used in monolithic technology : a slow wave appears only at very low frequency. A difference between experimental and theoretical attenuation is observed but it can be explained by the fact that the conductor losses have not been taking into account [8].

Fig.4 and Fig.5 show that the slow wave domain can be extanded if narrow strips are used although the slow wave factor decreases slightly.

Two other parameters are important : the conductivity and the thickness of the epitaxial layer.

It has been shown the existence of an optimum value of the conductivity [4,5] at which the attenuation presents a minimum and the slow wave factor a maximum. The slow wave domain can be also extended by the use of a large active layer but for monolithic application this parameter must be rather small

CONCLUSION

These results are a first contribution to the optimization of MIS and Schottky contact coplanar lines

The effects of all parameters on the slow wave domain are inspected. This step is necessary before making applications of these lines in monolithic technology.

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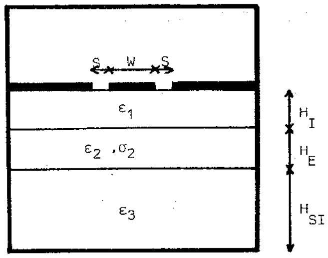
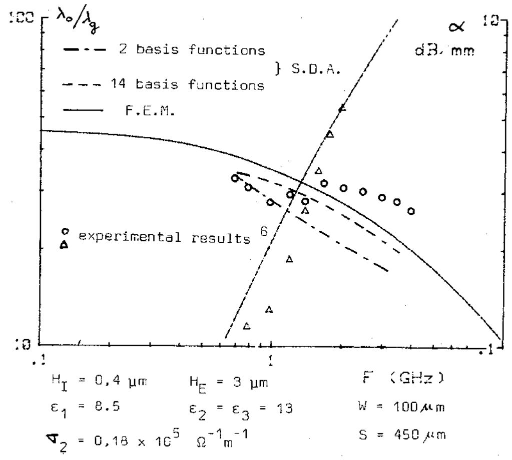
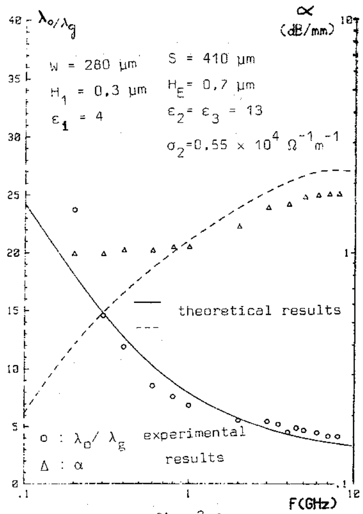


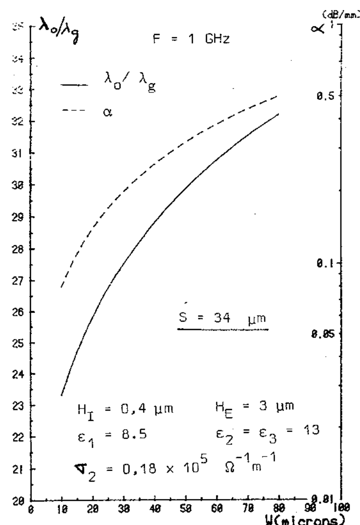
Fig.1 : MIS coplanar line.



- fig.2 -



- fig. 3 -



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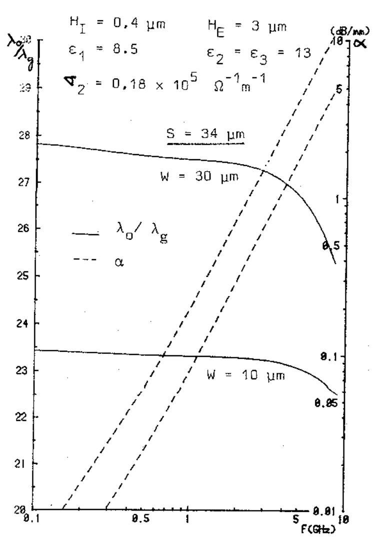

- fig.5 -

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