# Simple and Efficient Approach for Shunt Admittance Parameters Calculations of VLSI On-Chip Interconnects on Semiconducting Substrate

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## 1. Introduction

The purpose of this paper is a slight modification of a recently proposed series expansion method [1, 2], developed for the electrical modeling of lossy-coupled multilayer interconnection lines, that does not involve iterations and yields solutions of sufficient accuracy for most practical interconnections as used in common VLSI chips. We use here a Fourier series restricted to cosine functions. The solution for the layered medium is found by matching the potential expressions in the different homogeneous layers with the help of boundary conditions. In the plane of conductors, the boundary conditions are satisfied only at a finite, discrete set of points (point matching procedure).

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## 2. Main Results

To illustrate and validate the new proposed formulation, a coplanar strip interconnects structure shown in Fig. 1 is considered.

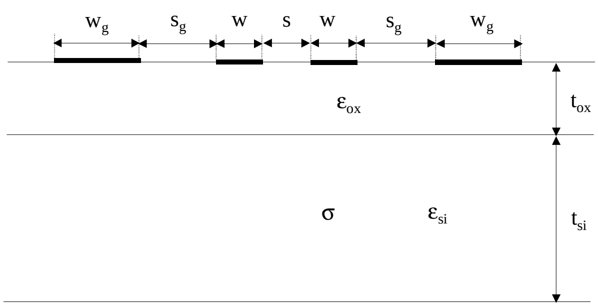
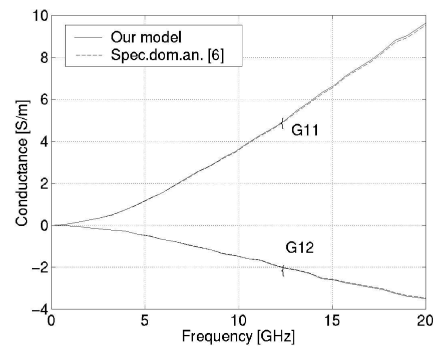



**Fig. 1. Symmetric coplanar coupled interconnect structure with two narrow signal lines and two wide ground metallization**

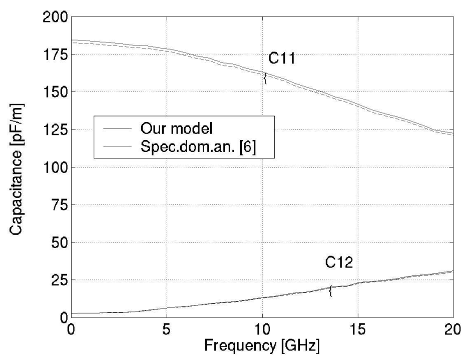
This symmetric interconnect geometry has the following electrical and geometrical parameters:

- $w = 2.0\ \mu m$, $w_g = 20\ \mu m$, $s = 2.0\ \mu m$, $s_g = 100\ \mu m$, $t_{ox} = 0.50\ \mu m$, $t_{si} = 500\ \mu m$, $\varepsilon_{ox} = 3.9\ \varepsilon_0$, $\varepsilon_{si} = 11.8\ \varepsilon_0$, $\sigma = 100$ S/m.

For comparison, the same symmetric coupled strip coplanar interconnect problem is also rigorously solved by using spectral domain approach [3] with Chebyshev polynomial basis functions weighted by appropriate edge factors. The conductance and capacitance per unit length of the coupled interconnects are calculated by using our point matching method as a function of frequency (f = 0 - 20 GHz), and compared with those of the spectral domain approach (full-wave solvers). We can see that the calculated results by our method are in very good agreement with the rigorous full-wave method solutions for whole frequency range. A comparison of the frequency response of the point matching-cosine Fourier series approach with that computed by the spectral domain technique [3] (Fig. 2a and b) shows that our approach yields very good results with little computation efforts.




(a)




(b)

**Fig. 2. Self and mutual shunt admittance components: (a) conductance per unit length and (b) capacitance per unit length.**

## 3. Conclusion

We have presented a point matching method and cosine Fourier series approach for shunt admittance parameter calculation of coplanar interconnect lines on lossy silicon substrate based on the quasi-stationary field analysis.

## References

[1] H. Ymeri, B. Nauwelaers, K. Maex, and D. De Roest, "Simple and accurate analysis of interconnects in high speed integrated circuits", *Microelectronic Engineering,* vol. 55, pp. 37 - 42, 2001.

[2] H. Ymeri, B. Nauwelaers and K. Maex, "Computation of capacitance matrix for integrated circuit interconnnects using semi-analytical Green's function method", *INEGRATION, the VLSI journal,* vol. 30, pp. 55 - 63, 2000.

[3]. E. Groteluschen, L. S. Dutta and S. Zaage, "Quasi-analytical analysis of the broadband properties of multiconductor transmission lines on semiconducting substrates", *IEEE Trans. Comp. Pack. Manuf. Technol., Part B*, vol. 17, pp. 376 - 382, August 1994.