SURFACE WAVE SUPPORTED BY A PLANAR SEMICONDUCTOR-DIELECTRIC INTERFACE AND ITS DISTRIBUTED CIRCUIT REPRESENTATION

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Surface wave interactions on a semiconductor distinguish themselves from others mediated by surfaces without free charges. The presence of mobile charges leads to both dissipation in the energy carried by the wave through conduction current and screening of the field from the interior of the semiconductor. The latter effect results in a more rapid decay in the transverse component of the electric field than that found in a surface wave guided by a dissipative dielectric having a similar loss tangent. Depending on the applications, such charge accumulation may be employed to provide controllable phase shift or it may be suppressed by external bias or otherwise to facilitate a low attenuation interconnect for components as found in RF integrated circuits.

A full-wave solution to the surface wave problem involving a semiconductor requires the coupling of the Maxwell's equations to the equations of motion of the charges in the semiconductor. Previous efforts have been made to identify the salient features of the resulting space-charge wave in the semiconductor but the formulation remains until today a computationally intense exercise. An investigation on a canonical structure aiming at obtaining a distributed circuit representation to enable the application of transmission line theory to the analysis and simulation of wave interactions in components on a semiconductor substrate would appear attractive.

In this work, the surface wave (TM) supported by a semiconductor-dielectric interface is analyzed in terms of the propagation constant, field and charge distribution, and the dependence of the wave impedance on the carrier concentrations and frequency. Considerations made on the results of analysis and the asymptotic behavior of computational outcomes led to the development of a distributed circuit representation for the structure in which each element can be justified by the physical process of charge-field interaction. An extension of the approach to the case of a metal-insulator-semiconductor structure was made to identify the features associated with a quasi-TEM wave that propagates along a semiconductor surface. Results of computation carried out for structures with typical material parameters will be presented. The assumptions and the range of validity of the distributed circuit representation will be discussed.