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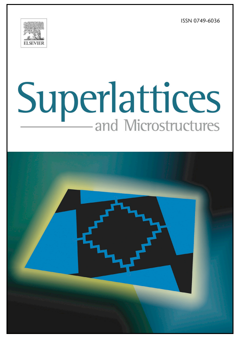

Metal-insulator-metal waveguide based passive structures analyzed by transmission line model

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Metal-insulator-metal waveguide based passive structures analyzed by transmission line model

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Abstract—In this work, we present an accurate coupled transmission line model for different metal-insulator-metal waveguide based arrangements. The coupling regions are modeled by appropriate characteristic impedances and propagation constants for the both even and odd modes, which are calculated from the metal-insulator-metal waveguide parameters. The effectiveness of the transmission line models is investigated by using fully numerical finite element method (FEM) technique. Our theoretical transmission line models of proposed structures are in good agreement with FEM based COMSOL simulations**.**

Index Terms—Metal-insulator-metal waveguide, coupled transmission lines, impedance, equivalent circuits, and plasmons.

I. INTRODUCTION

Generally, MIM waveguides support fundamental TM_0 mode [1], [2]. These days plasmonic oscillations are achieved mainly through V-grooves on metal layers [3], nanowires [4], array of metal nanoparticles [5], MIM waveguides [6], IMI waveguides [7] and hybrid plasmonic waveguides [8]. Due to its advantage of strong electromagnetic field localization in the visible and infra-red region, MIM waveguides are most favorable candidate for many plasmonic components, and sensing applications. Over the last few decades, many research groups proposed many passive devices based on metal-insulator-metal waveguide structures like MIM bends [1], T-junctions [1], filters [9-10], splitter [11], resonator [12], coupler [13]and de-multiplexer [14-15] etc. The fabrication details of similar structures are available in ref. [16].

The validation of MIM waveguide structures using transmission line modeling (TLM) is quite famous these days. A distributed circuit model for MIM stubs [17], [18], power divider [1], filters [19], switches [20] and resonators [21] etc. is already developed with well-known transmission line theory. Researchers extract the S-parameters from mutual inductances, capacitances of MIM structures following TLM and check their accuracy by performing either FEM or FDTD simulations. Hence, propagation constant and device parameters are key factors for these MIM device to formulate their respective circuit TLM models. Some groups also used temporal and spatial coupled mode theory to study circuit modelling of passive MIM structures, but these theories require additional calculation of coupling coefficients. Therefore, these days transmission line models of MIM structures are bringing microwave engineering theories and plasmonic concepts closer and closer.

In addition, the interesting work is available in ref. [14], where the MIM waveguide arrangements are interchanged by their respective transmission line sections. From device parameters, authors calculated both characteristic impedance and propagation constant. In this way, the whole geometry is converted to the transmission line based lumped circuit. Finally, they apply the conventional microwave network theory to calculate per-unit

.