The University of Electro-Communications

Global Analysis for a Surface Wave Mode HFET Amplifier Module at 60 GHz by EM-Device Co-Simulation

Abstract - A global analysis for a millimeter-wave amplifier module with surface wave mode transmission lines has been demonstrated. The analysis method is a co-simulation between an FDTD-based electromagnetic simulator and a semiconductor device simulator. Using this method, it is possible to consider various electromagnetic coupling between transmission lines and active devices with nonlinear characteristics. Furthermore, a semiconductor device simulation is more accurate than an approximation to a large-signal equivalent circuit. The incorporated simulation was demonstrated for a millimeter-wave amplifier module which consists of an HFET and planar dielectric transmission lines (PDTL) at 60-GHz region. The PDTL with a surface wave transmission mode has a low-loss transmission characteristic at millimeter-wave region using a low-loss ceramic substrate. However, the transmission wave on the PDTL tends to be scattered by discontinuity structures and impedance mismatching. Furthermore, it is predicted that reflected scattered waves at edges of the substrate interfere the PDTL and transistors mounted on the PDTL. Using the co-simulation technique, influence of the scattering waves was investigated in detail for the amplifier module.

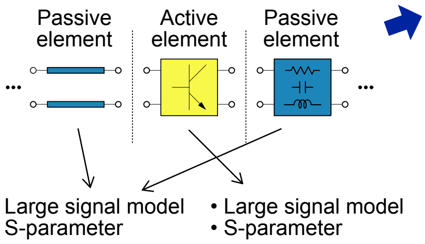
INTRODUCTION

• Design of High Frequency Components

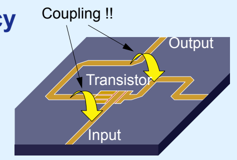
Design tools for High frequency components

- Electromagnetic simulator
  (Finite element method, Moment method)
  ••• Antenna, Filter, etc.
- Circuit simulator (SPICE, Harmonic balance)
  ••• Amplifier, Modulator, etc.
- Device simulator (T-CAD)
  ••• Compound semiconductor device, etc.

Connecting each component



More high frequency More miniaturized



- Unpredicted EM-coupling
- Accuracy limit of large signal model

Solution

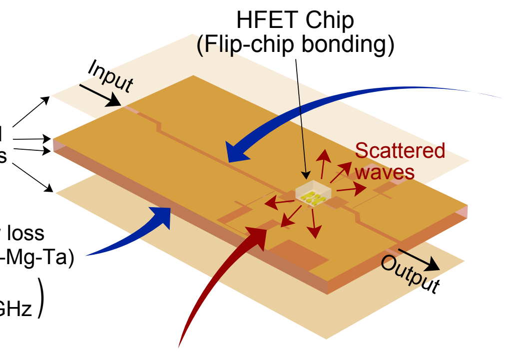
EM-Semiconductor Device Co-simulation Technique

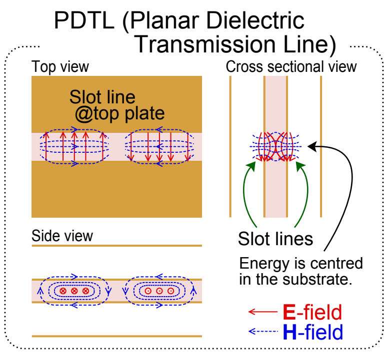
• Millimeterwave PDIC Amplifier Module

PDIC : Planar Dielectric Integrated Circuit

Proposed by Murata Manufacturing Co., Ltd.

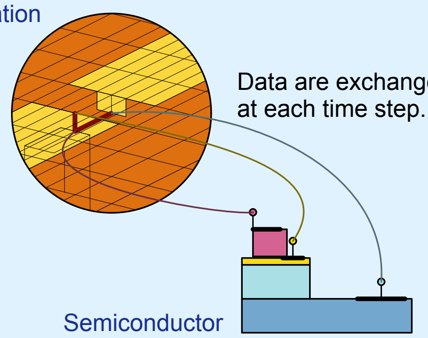
- Small size
- Low Loss
  @millimeterwave region

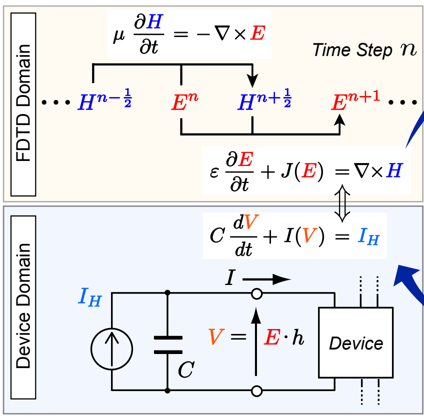


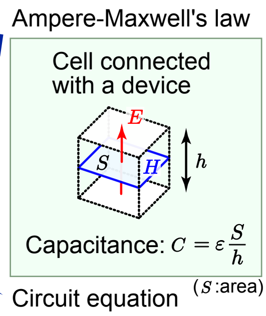


Inputted wave is scattered at the HFET because of an irregular structure and mismatching. ➡ The influence can be estimated by the EM-device co-simulation technique

FDTD ELECTROMAGNETIC - SEMICONDUCTOR DEVICE CO-SIMULATION TECHNIQUE







Electromagnetic-field data in the FDTD domain are transported to the device simulation circuit by using the above-mentioned relation. And device simulation results are returned to the FDTD cell according to FDTD time-steps.