Plasmonic Waveguide Analysis

User Presentations, - RF, Microwave and Plasma

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8 October 2015

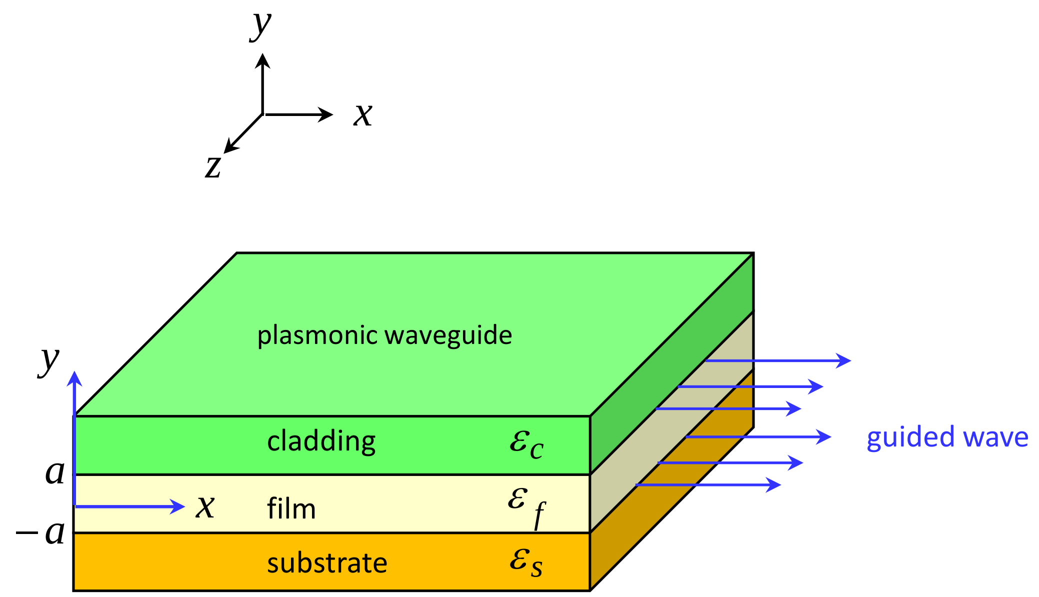
Objective

- Provide comparison of numerical and analytic solutions for a plasmonic waveguide
- Extend solution method to surface plasmon coplanar waveguide

What is a Surface Plasmon?

- Electromagnetic excitations that propagate at the interface between a dielectric and a conductor
- Evanescently confined in the perpendicular direction to the propagation
- Arise by coupling of the electromagnetic field to oscillations of the conductor's electron plasma
- Everyday example – stained glass

Plasmonic Waveguide Geometry



Only TM plasmonic modes will be considered

Dielectric-metal dielectric (DMD) and metal-dielectric-metal (MDM)

Two-dimensional model

Physics

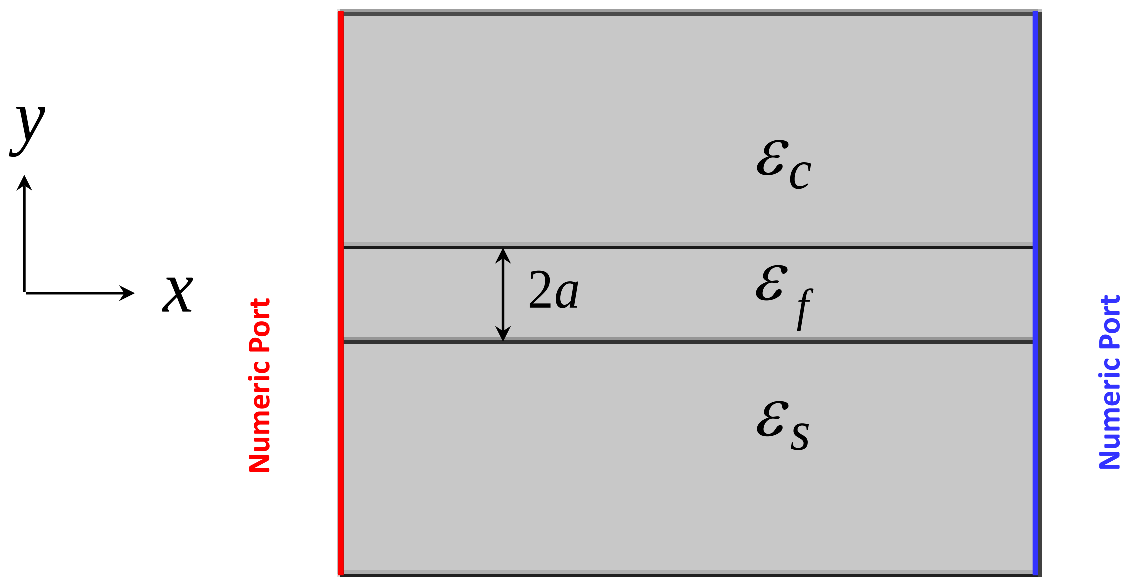
Maxwell's Wave Equation: $$\nabla \times \frac{1}{\mu_r}(\nabla \times \mathbf{E}) - k_0^2\left(\varepsilon_r - \frac{j\sigma}{\omega\varepsilon_0}\right)\mathbf{E} = 0$$

Electromagnetic Waves, Frequency Domain (emw) physics interface is used to solve governing equation

Electric field components are solved for "*In-plane vector*".

Physics – Boundary Conditions

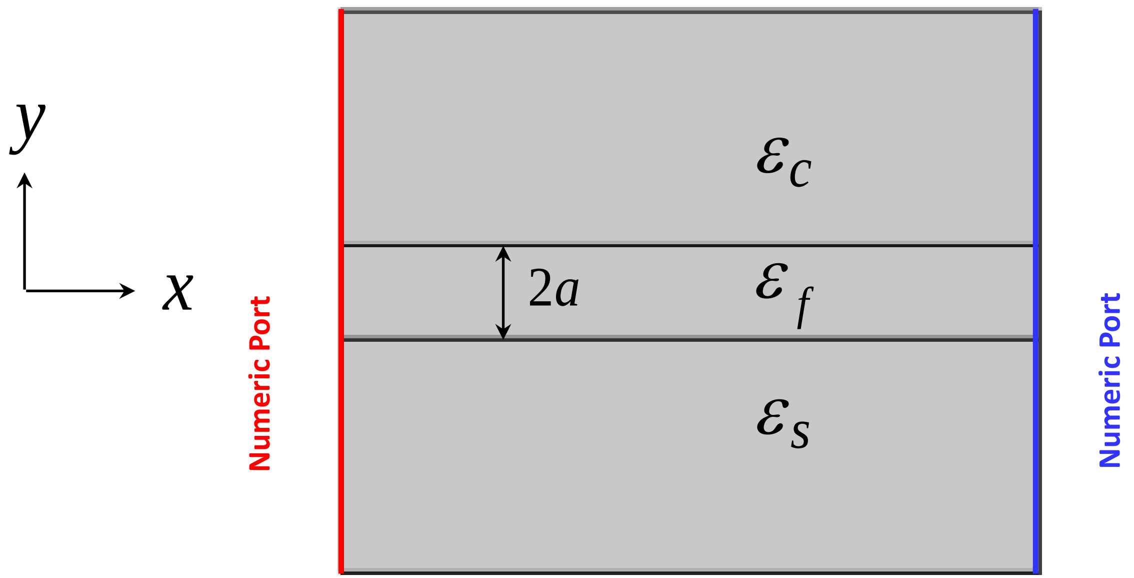
Boundary Conditions Irrelevant
Far from interface



Wave excitation = "On"
Launches wave

Wave excitation = "Off"
Maintains mode of
launched wave in x -dir

Material Properties – Dielectric Constants



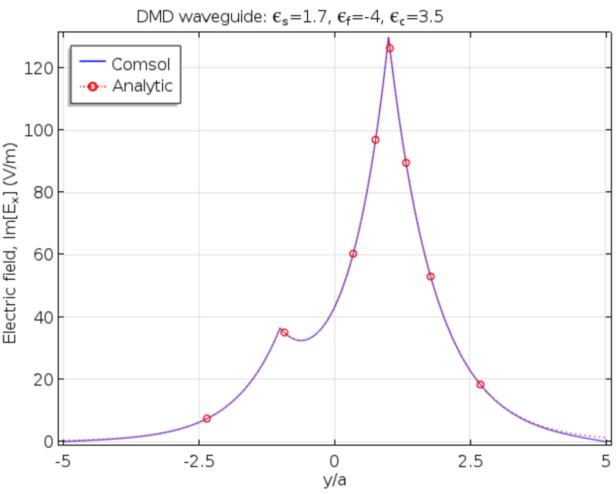
Configuration	Substrate, ε_s	Film, ε_f	Cladding, ε_c
DMD	1.7	-4	3.5
MDM	-1.6	2.2	-4

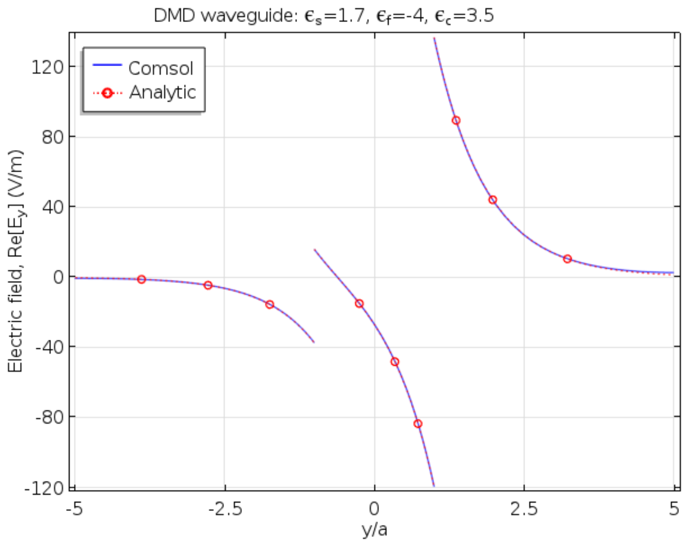
Solution Method

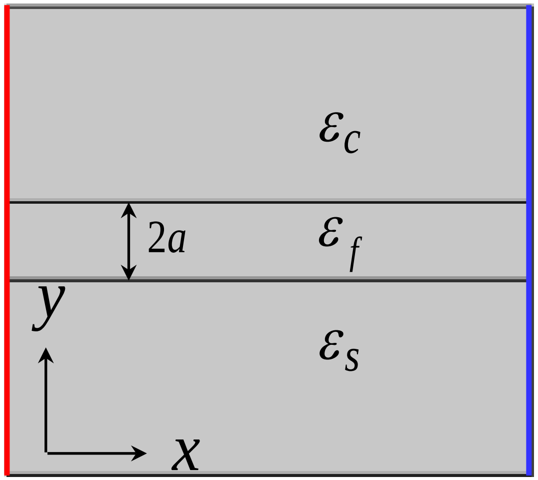
- Two boundary mode analysis steps
  - Eigenvalue solution for the fields and propagation constants at the boundaries
- Frequency domain step

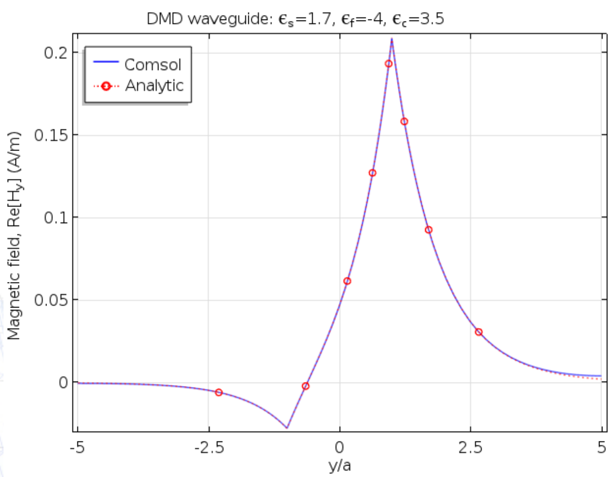
Comparison with Analytic Solution

DMD waveguide: ϵ_s=1.7, ϵ_f=-4, ϵ_c=3.5



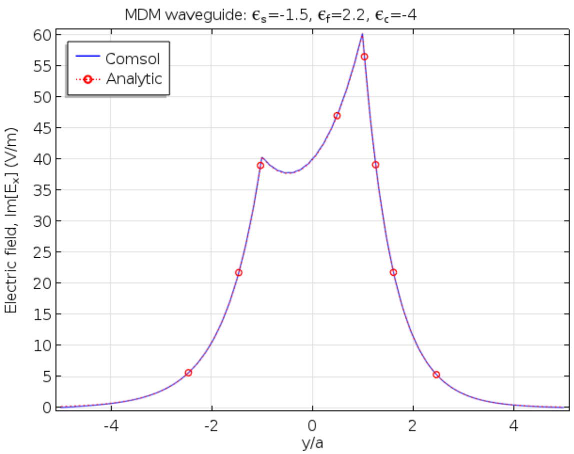


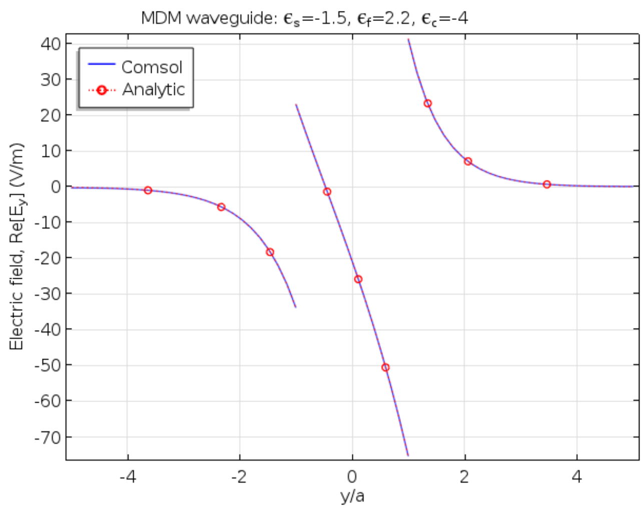


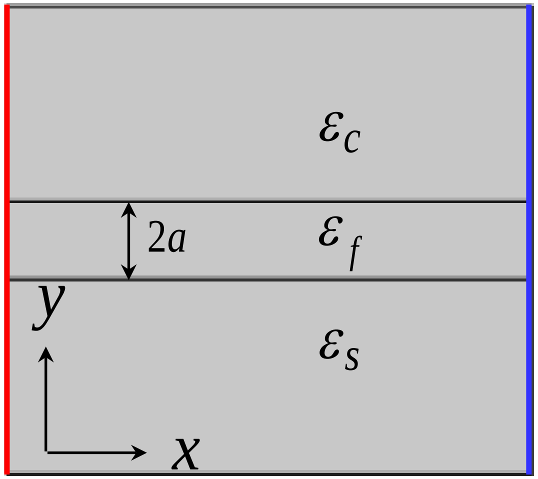


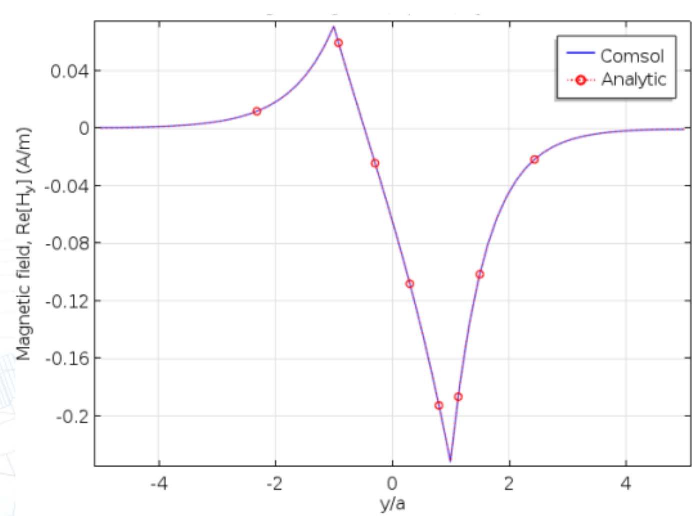
Comparison with Analytic Solution

MDM waveguide: ϵ_s=-1.5, ϵ_f=2.2, ϵ_c=-4

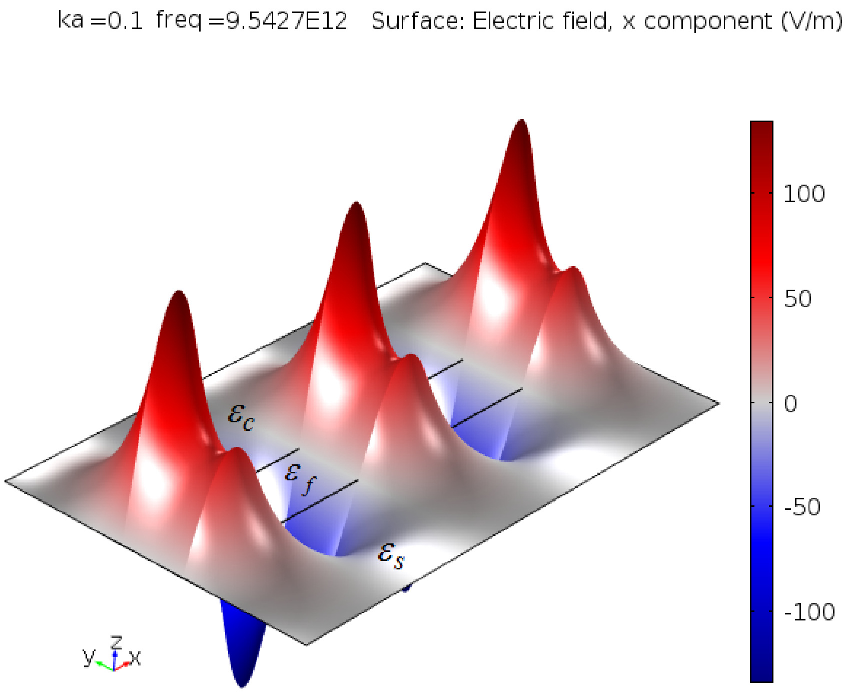




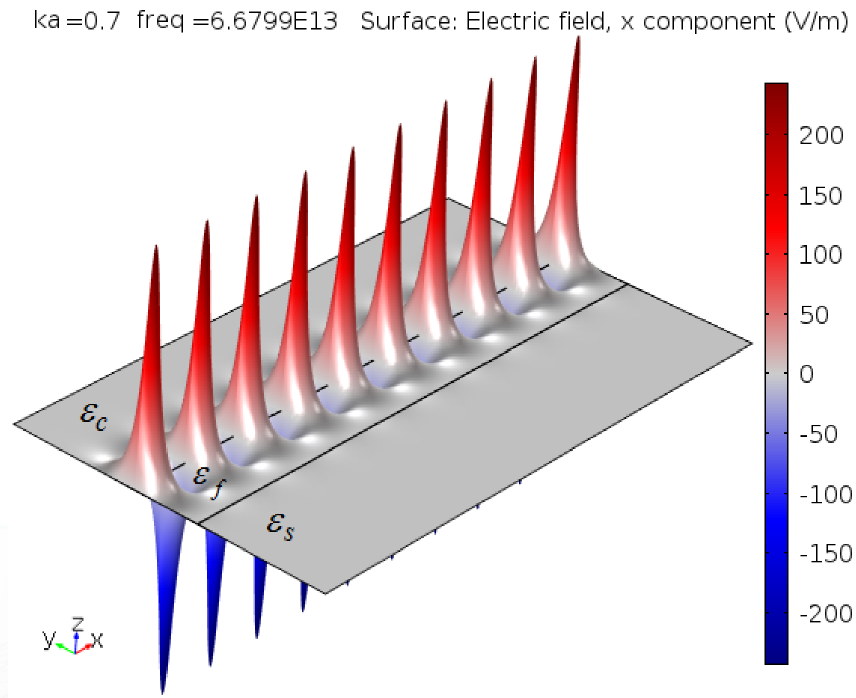




Electric field distribution - DMD waveguide

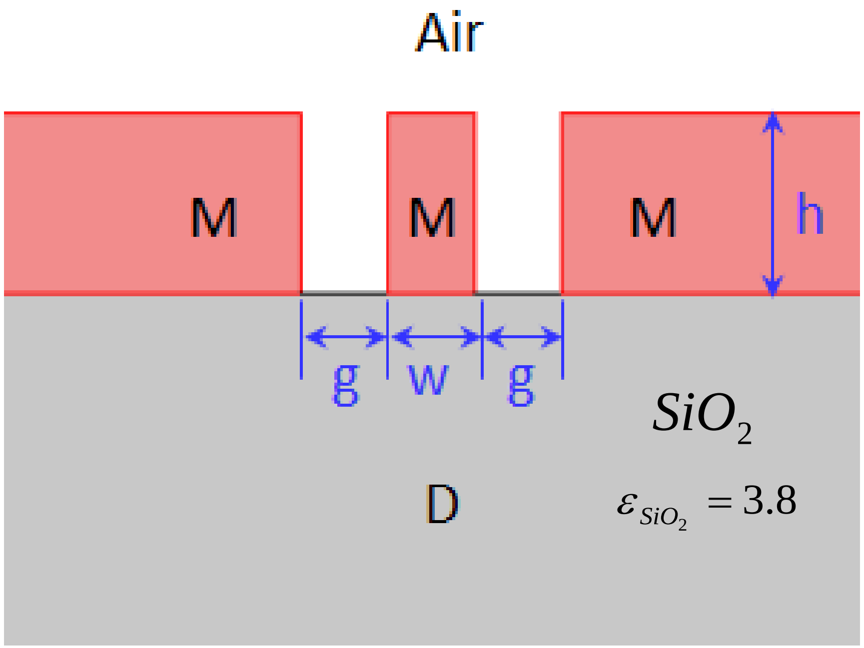


$f = 9.54THz$



$f = 66.8THz$

Coplanar Waveguide Problem



Silver

Drude model dielectric function

$$w = g = 50nm$$

$$h = 100nm$$

$$\lambda_0 = 1500nm$$

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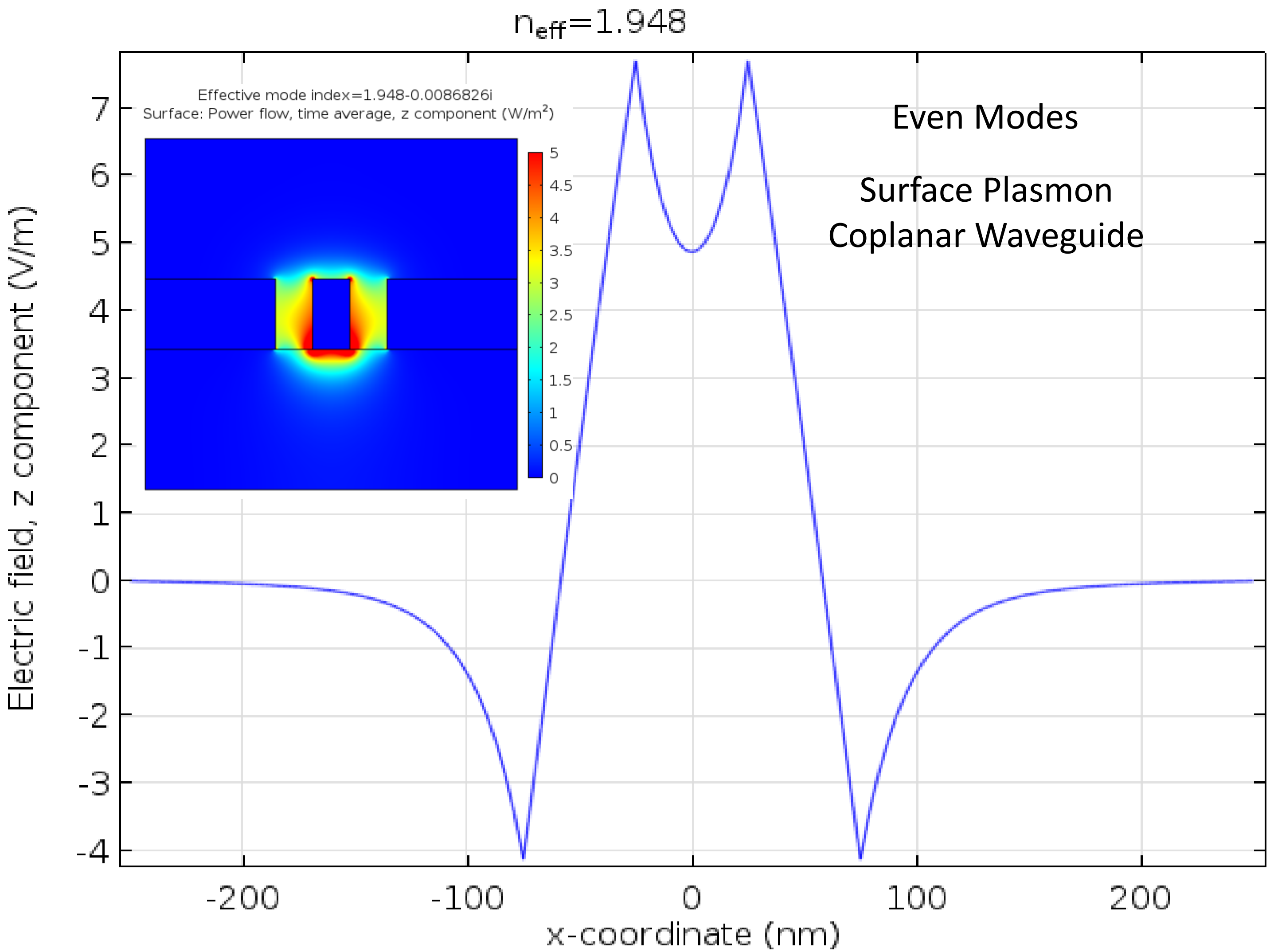
Electric Field – Longitudinal Component



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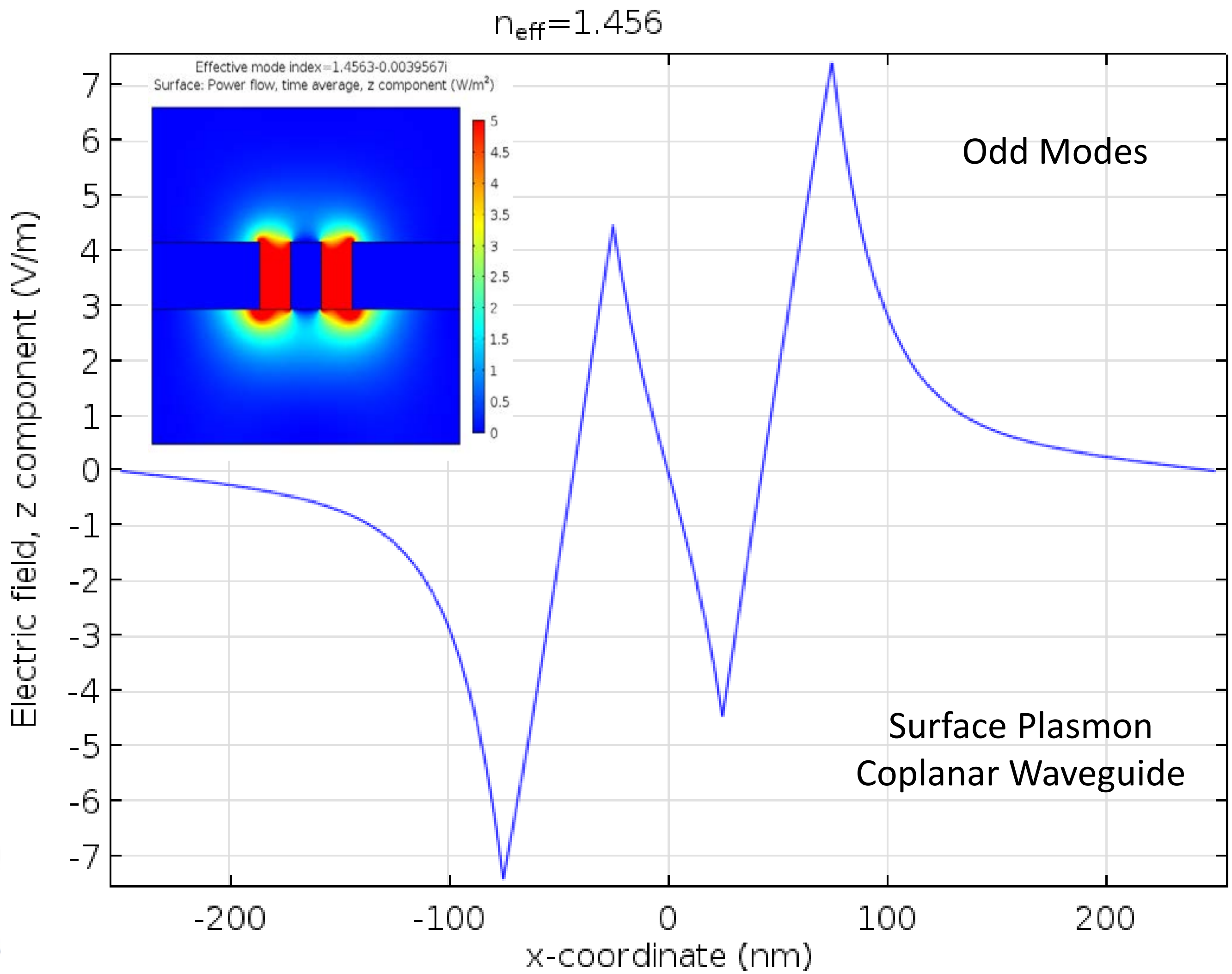

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Summary

- Plasmonic layered waveguide (DMD and MDM) analyzed
- Comparison with analytical solution verifies methodology
- Technique extended to surface plasmon coplanar waveguide