Waveguide and Directional Coupler **MODE Simulation** 1885

High-Speed Circuits & Systems Lab. Dept. of Electrical and Electronic Engineering Yonsei University

Lumerical Solutions

3D Maxwell solver(FDTD)

Our Products



FDTD Solutions: Single and multiprocessor finite-difference timedomain optical design software. Product Details | Trial Download



MODE Solutions: Waveguide eigenmode solver and omnidirectional broadband propagator design software. <u>Product Details | Trial Download</u>



INTERCONNECT: Optoelectronic and photonic integrated circuit (PIC) design software package. Product Details | Trial Download



DEVICE: Powerful semiconductor TCAD device simulation software for silicon-based optoelectronic structures.

Product Details Trial Download



Modal analysis(MODE)



Charge transport & heat transfer(DEVICE)





Lumerical MODE Solution

• FDE(Finite Difference Eigenmode) solver

-Calculate physical properties of **waveguide modes** -Solve Maxwell's equations for cross-sectional mesh



2.5D varFDTD(Finite Difference Time Domain)
 Time domain simulation with approximation

-2D simulation speed with 3D accuracy



Most simulations will be held with these solvers

• EME(Eigenmode Expansion) solver

-Frequency domain simulation



License Setting

Floating Node Locked Manage which floating license servers get checked from this tab. Options Options Server: 165, 132, 112, 189 Port: Default Specify Configure redundant servers Server can be either the hostname or IP address of a Flex license server Actions Apply these settings to my user account only Make these settings to my user account only Make these settings the system defaults (requires elevation) Configure my account to use system defaults Instructions on how to activate your floating license View your active licenses in the FlexNet Publisher dashboard OK Cancel	MODE Solutions - Configure License	? <mark>×</mark>
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MODE Window

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Command Window	Script Workspace B ×
Group scope= ::model Directory: D:/mk/Simulations/Carrier Injection Modulator Normalization: CWNorm	Script Workspace Script Favorites



Waveguide Structure

Drawing structure

- Example) Make strip waveguide
- Height: 220 nm
- Width: 500 nm
- Length: 30 µm
- Core material: Si
- Cladding material: SiO₂











Cladding

Edit rectangle	🧭 Edit rectangle	
name test_clad Geometry Material Rotations Graphical rendering x (µm) 0 x min (µm) -2 x span (µm) 4 x max (µm) 2 y (µm) 0 y min (µm) -15 y span (µm) 30 y max (µm) 15 z (µm) 0 z min (µm) -2 z span (µm) 4 z max (µm) 2 v use feature to the second se	name test_clad Geometry Material Rotations Graphical rendering Optical material material SiO2 (Glass) - Palik index see material database index units microns v override mesh order from material database mesh order 3 Grid attributes grid attribute name	Mesh order: If materi folded, choose mater which has smaller me order corder
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Cladding





• Core

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Eigenmode Solver

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Mode list	DECK
mode # effective index wavelength (μm) loss (dB/cm)	TE polarization fraction (Ex) w. name wavelength (µm)
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wavelength (µm) 1.55	
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Simulatio	on



MODE Solutions





Confinement Factor

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Group Index(ng)





Sweep Width

Sweep waveguide width from 100nm to 300nm with 50nm step

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Type Ranges	▼ Number of points: 5						
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Sweep Results





Design Exercise 2-1

What is the single-mode condition for the given thickness of rib waveguide? Also, calculate group index(n_g) for the single-mode rib waveguide.

-220nm thick & 100nm slab at 1550nm

Due: 27 Nov. in class





Tips for Design Exercise 2-1

- Condition for guidance of rib waveguide
 - :n_{eff_total}>n_{eff1} :Making same environment as strip waveguide
- How to get n_{eff1}
 :Use 1-D Z:X prop simulation in FDE solver





Rib Waveguide





Waveguide coupler

• Y-branch coupler



- Ideally 50:50 power splitter
- Bezier Curve
- Curve shape change due to x2, y2



Y-branch coupler





• Download y_splitter.lms file at YSCEC

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Structure (cladding)

Rectangular

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name cladding	
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• 2.5D FDTD Solver Setting(Variational FDTD Solver)

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Optoelectronics (17/2)

(Yonsei University





• Monitor 1 Setting (Frequency domain field and power)

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name monitor_1	name monitor_1
General Geometry Data to record Spectral averaging and apodization	General Geometry Data to record Spectral averaging and apodization Advanced
🔽 override global monitor settings	
🔲 use linear wavelength spacing	monitor type 20 X-normal
✓ use source limits	x (µm) 45 x min (µm) 45
wavelength	x span (µm) 0 x max (µm) 45
minimum wavelength (μ m) 1.5	y (μm) 10 y min (μm) -0.5
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output Ez output Hz voutput Pz	<u>OK</u> <u>Cancel</u>

-Frequency point should be large enough





• Monitor 2 Setting (Frequency domain field and power)

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output Ez output Hz votput Pz votput power				

-Frequency point should be large enough



Run Simulation

• After setup, run simulation





Result

- Monitor 1 (Right click) \rightarrow Visualize \rightarrow T
- Monitor 2 (Right click) \rightarrow add to visualizer 1 \rightarrow T





Design Exercise 2-2

Design rib waveguide type Directional Coupler. Use waveguide width from the result of Design Exercise 2-1.

-220nm thick & 100nm slab at 1550nm

Hame Origin * (um) *	📡 Edit structure group		XY view 8
User properties * Name Type Value Unit 1 f! wg_vidith Length 0.5 um 2 i! wg_idight Length 0.22 um 3 i! wg_idight Length 0.1 um 4 it_coopling Length 0.1 um 5 i! gap Length 1.0 um 6 i! x1 Length 1.0 um 7 f! x2 Length 2.0 um 9 Material_SIO2 Material SIO2 (Glass) - P.	name directional coupler Properties Script Rotations Origin x (μm) 0 y (μm) 0 v use relative coordinates	z (μm) 0	
	# Name Type Value 1 l wg_width Length 0.5 2 l wg_height Length 0.22 3 l' wg_slab Length 0.1 4 l L_coupling Length 10 5 l' gap Length 10 7 l' x2 Length 20 9 Material_Si Material Si (Sili) 10 Material_SiO2 Material Si O2 (G	Unit um um um um um um um icon) - Pa (Glass) - P ØK Cancel	

Due: 27 Nov. in class

