ECE 480A8: Waves in Photonic Integrated Circuit Elements

IN

Physics and Engineering

- Basic knowledge about optics and waves including basic units, wave phenomena, and energy-frequency-wavelength relations
- Familiarity with Maxwell's equations and their time-harmonic solutions represented as complex quantities
- Definition and use of frequency-dependent complex dielectric constant and material absorption
- EM wave eq'n and solutions including transmission and reflection at dielectric boundaries, dependence on polarization

Mathematics

- **Apply** differential equations with boundary conditions and their solutions to physical problems

Computer Science

- Compute and plot solutions to algebraic equations
- Manipulate data including in arrays

Pre-requisites

- ECE340 with a minimum grade of C or ECE342 with a minimum grade of C; MATH340 with a minimum grade of C; PHYS142 with a minimum grade of C; CS162 with a minimum grade of C or CS163 with a minimum grade of C or CS164 with a minimum grade of C

Concepts:

- Brief review of EM waves
- Typical structure of PICs
- Common passive elements of PICs including waveguides, splitters, couplers, interferometers, resonators, modulators, gratings, and reflectors
- Impact of PIC elements on amplitude and phase of EM waves
- Spectral dependence of wave propagation in PICs

Applications:

- Impact of spectral properties of PIC elements on optical communications
- Use of PIC-based MZIs for refractometry
- Use of PIC-based ring resonators for refractometry
- Use of PIC gratings for spectral filtering

Tools:

- **Mathematics:** Algebra of complex variables; calculus; differential equations; small matrices
- **Small programming**: Matlab, Python, or other common languages of student's choice for calculations and plotting
- **Online calculators**: 1-D optical waveguide modes using free online calculators

OUT

PIC Structure & Overview

- List and distinguish PIC elements
- Identify, draw, and discuss PIC layers

EM Waves in Waveguides

- Recognize and use EM equations and solutions for modeling waveguide modes.
- Calculate and plot transverse mode profiles.
- Apply EM boundary conditions to TE and TM modes

Analysis of Specific PIC Elements

- Calculate I/O relationships for amplitude and phase of PIC elements in steady-state
- Multimode-interference devices
- Amplitude & phase modulators
- PIC-compatible interferometers
- Ring-resonators
- Periodic index structures

Modal overlap analysis

- Calculate and apply confinement factors for waveguide modes
- Calculate coupling and overlap factors between different modes in waveguides

Revised 4/2024