Integrated photonics

Component
École Nationale Supérieure d'Électrotechnique d'Électronique d'Informatique d'Hydraulique et des Télécommunications

In brief

- **Ametys Code:** M34HPMTN
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:
- Understand the fundamental principles of guided light propagation in integrated media.
- Analyze and design the basic structures of integrated photonics (edge couplers, grating couplers, optical filters, Mach-Zehnder interferometers, microring resonators, arrayed waveguide grating waveguide networks, modulators, etc.).
- Use advanced simulation tools (EME, FDTD 2D, 3D) for modeling and optimizing integrated photonic components.
- Design an integrated refractometer for biomolecule detection using appropriate simulation software.
- Interpret and analyze simulation results to evaluate the performance of the designed devices.
- Write a detailed design report presenting the methodology, design choices, and performance of the device.

Description

1. Introduction to integrated photonics
Review of the basic principles of guided optics: propagation equations, guided modes, dispersion.
Concept of effective index, group index.
Comparison of the main integrated photonics platforms (silicon, SiN, etc.).
Comparison of optical fiber and integrated photonics

2. Fundamental structures and passive components
Optical coupling: edge coupler, grating coupler. Passive structure: Single optical waveguide, curved optical waveguide, Y-splitter, multi-mode interferometer, directional coupler.
Interferometers and optical filters: Mach-Zehnder interferometer (MZI), resonant rings (microring resonator), waveguide gratings (AWG).
3. Active components and modulators
Principles of optical modulators: electro-optical, thermo-optical, and acousto-optical modulators.
Opto-electronic detection and conversion.
4. Simulation tools and techniques
Introduction to simulation methods: Eigenmode Expansion (EME) and Finite-Difference Time-Domain (FDTD) methods.
Getting started with simulation software and parameterization of photonic structures.
5. Design office: design of an integrated refractometer
Project specifications: detection of biomolecules via a change in refractive index.
Design and optimization of the structure using simulation software.
Performance analysis and validation of the device.
Drafting of a detailed design report.

Pre-requisites

Electromagnetism

Guided propagation

Optoelectronics

Optoelectronics lab