Integrated photonics

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

In brief

- **Code ELP:** N9EE46A
- **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

Non-contractual information.
Last update on 29 October 2025

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

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