GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2025-2026

Integrated Photonic (Bio)Sensing (E030480)

Course size *(nominal values; actual values may depend on programme)*

Credits 4.0 **Study time 120 h**

Course offerings in academic year 2025-2026

A (semester 2) English Gent

Lecturers in academic year 2025-2026

Le Thomas, Nicolas TWO5 lecturer-in-charge

Offered in the following programmes in 2025-2026	crdts	offering
Master of Science in Silicon Photonics	4	A

Teaching languages

English

Keywords

PICs, optical sensing

Position of the course

Expose the students to various basic concepts

Contents

- Introduction to fundamental and practical reasons for using PICs for sensing.
- Key building block of PICs in the context of sensing: waveguide and light conversion efficiency in guided mode, ring resonator for sensing and spectral analysis, filters, integrated spectrometers, integrated sources, gratings, phased array waveguides, photonic crystals, integrated MZI, on-chip light sources for sensing (laser, combs, LEDs).
- Limit of detection: A key figure of merit
  - Definition, trade-offs in terms of bandwidth
  - Practical aspects: electrical noise, photodiode noise, laser noise, CMOS/CCD imager noise, Allan variance
  - Intrinsic thermo-refractive noise
  - Fundamental high frequency noise
  - Low noise detection techniques on-chip compatible: Homodyne, heterodyne, Pound-Drever-Hall detection.
- Principle for sensing matter
  - Refractive index sensing and biosensors
  - On-chip spectroscopy: infrared absorption spectroscopy, fluorescence, Raman spectroscopy
  - Integrated spectrometers
- Space sensing: Beam shaping
  - chip-based LIDAR
  - Intrinsic thermo-refractive noise
  - On-chip gyroscopes principle, state of the art in terms of detection limit
- Space sensing: Interferometry
  - Remote sensing
  - Laser Doppler Vibrometer
- Sensing time and gravity sensing:
  - Principle of optical clocks
  - On-chip implementation
  - Atom chip gravimetry
- Sensing electromagnetic field:

- On-chip magnetometry with NV centers in diamond
- PIC-based electric field sensors
- Principle of optical microscopy: A k-space approach
  - Super-resolution with PIC: near-field and far-field
  - Beam shaping for microscopy quantitative phase imaging
  - X-ray on chip
- Microfluidic for on-chip sensing

Initial competences

Basic physics, optics and electromagnetics

Final competences

1 Understand the fundamental physical principle used by PICs for sensing and be aware of all the opportunities that photonic integrated circuits can offered in this context.
2 Have a general overview of the different photonic integrated circuits already in used for sensing applications.
3 Be able to quantify the signal provided by photonic integrated circuit and the detection limit.
4 Have knowledge about all the existing building blocks used in photonic integrated circuits to implement sensing.
5 Be able to design a photonic integrated circuit, in particular to select the proper integrated photonic building blocks, for a given sensing application.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture, Independent work

Study material

Type: Slides

Name: Slides and course notes used during the course
Indicative price: € 11
Optional: no
Additional information: Available electronically (free) or through the student organization (8 /11,5 Euro member/non-member)

References

Course content-related study coaching

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Written assessment open-book

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Written assessment open-book

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

- During examination period: written open-book assessment and oral closed-book assessment.
- During semester: graded homework.

Calculation of the examination mark

30% written, 40% oral exam, 30% homework.