GHENT UNIVERSITY

# Course Specifications

Valid as from the academic year 2024-2025

## Physics of Advanced Electronic and Photonic Devices (E006200)

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

**Credits 6.0** **Study time 180 h**

**Course offerings and teaching methods in academic year 2024-2025**

| | | | |
|---|---|---|---|
| A (semester 1) | English | Gent | seminar |
| | | | lecture |
| B (semester 1) | Dutch | Gent | |

**Lecturers in academic year 2024-2025**

| | | |
|---|---|---|
| Strubbe, Filip | TWO6 | lecturer-in-charge |
| Van Thourhout, Dries | TWO5 | co-lecturer |

| **Offered in the following programmes in 2024-2025** | **crdts** | **offering** |
|---|---|---|
| Master of Science in Engineering Physics | 6 | B |
| Master of Science in Engineering Physics | 6 | A |

**Teaching languages**

English, Dutch

**Keywords**

Nano-electronics, spintronics, 2D materials, nano-photonics, photonic crystals, electro-optic modulators, displays, light detection, solar cells

**Position of the course**

The aim of this course is to provide a detailed study of the physics of advanced electronic and photonic devices. The course will start with the physics of advanced and emerging electronic devices in which novel effects are employed to surpass the properties of traditional silicon semiconductor devices. In the second part, the physics of passive nano-photonic devices will be studied, with special attention to the behavior of light in high-index contrast configurations and photonic crystals. In the third and last part, devices with an important interplay between electronic and photonic effects will be discussed. In particular electro-optic effects in which an quasi-static electric field results in a change of optical properties will be studied in detail. Also the physics of light detection and harvesting devices such as solar cells will be treated in detail.

**Contents**

**1. Nano-electronics**

Physics:
1 Heterojunction, 2D electron gases
2 Spintronics: (Giant) Magnetoresistivity, Magnetic Tunnel Transistor
3 Band structure of 2D-materials (graphene, MoS2, ...)
4 Superconductivity (Josephson junction, interaction with EM field)
Devices & applications: Memory (NAND-RAM, FERAM, MRAM), Logic gates (High-Electron Mobility Transistors, Monolithic Microwave Integrated Circuits (MMICs), power switching transistors, graphene transistors, superconducting logic)

**2. Nano-photonics**

Physics:
1 Light in high-index contrast waveguides (mode analysis, propagation, dispersion, parameter sensitivity)
2 Coupled mode theory (directional couplers, ...)

3 Periodic structures and photonic crystals (band diagram)
4 High Q cavities and slow light waveguides
5 Plasmonics
Devices & applications: Transceivers for telecom and datacom, Sensors and bio-sensors, Plasmonics for sensing and interconnects, Brillouin and Raman sensors

**3. Electro-optic interaction in materials**

Physics:
1 Anisotropy, crystal symmetry, index ellipsoid
2 Nonlinear susceptibility, electro-optics effects: Kerr & Pockels effect
3 Acousto-optic effect
4 Soft matter (liquid crystals)
Devices & applications: High-speed modulators for telecom, Acousto-optic modulators, Displays (Liquid crystal displays)

**4. Light detection and harvesting**

Physics:
1 Interplay of light absorption and band structure in illuminated diodes
2 Thermodynamic principles for maximum efficiency of light to electrical power conversion
3 Novel material systems (thin film: organic, perowskite, kesterite)
4 Light management: incoupling of light, back contact reflection
Devices & applications: Photodiodes, CMOS sensors (cameras), Solar cells, Single-photon detectors

**Initial competences**

Materials & Fields, Photonics, Solid State Physics, Quantum Mechanics I & II, Physics of Semiconductor Devices

**Final competences**

1 Understand the physics of advanced electronic and photonic devices.
2 Understand the physics of devices in which there is an important interplay between electronic and photonic effects.
3 Numerically simulate opto-electronic devices and understand important design parameters of such devices related to the interaction between electronic and photonic effects.
4 Obtain insight into the different applications of advanced electronic, photonic and opto-electronic devices.

**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

**Extra information on the teaching methods**

Lectures and coached exercise seminars, 4 lab sessions

**Study material**

Type: Syllabus

Name: Physics of advanced electronic and photonic devices
Indicative price: Free or paid by faculty
Optional: no
Language : English
Number of Pages : 427
Oldest Usable Edition : 2023
Available on Ufora : Yes
Online Available : Yes
Available in the Library : No
Available through Student Association : No

**References**

1 Shun Lien Chuang, “Physics of Photonic Devices, 2nd Edition” (Wiley), ISBN: 978-

0-470-29319-5
2 Safa Kasap, Peter Capper, “Springer Handbook of Electronic and Photonic Materials” (Springer, 2017), ISBN 978-3-319-48933-9

**Course content-related study coaching**

The instructor(s) can be contacted after the lectures, or by appointment.
Interactive support via the electronic learning platform.

**Assessment moments**

end-of-term and continuous assessment

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

Oral assessment, Written assessment with open-ended questions

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

Oral assessment, Written assessment with open-ended questions

**Examination methods in case of permanent assessment**

Assignment

**Possibilities of retake in case of permanent assessment**

examination during the second examination period is not possible

**Extra information on the examination methods**

- periodic evaluation: written and oral examination with open questions, both theoretical and exercise part
- Non-period-bound evaluation: evaluation of reports of lab sessions. A resit is not possible, the score from the first examiniation period is copied to the resit period.

**Calculation of the examination mark**

- Evaluation during exam period 70%.
- Lab sessions 30%.