GHENT UNIVERSITY

# Course Specifications

Valid as from the academic year 2024-2025

## Physics of Semiconductor Technologies and Devices (E031521)

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

**Credits 4.0** **Study time 120 h**

**Course offerings and teaching methods in academic year 2026-2027**

| | | | |
|---|---|---|---|
| A (semester 2) | English | Gent | practical<br>lecture |
| B (semester 2) | Dutch | Gent | |

**Lecturers in academic year 2026-2027**

| | | |
|---|---|---|
| Van Steenberge, Geert | TW06 | lecturer-in-charge |
| Missinne, Jeroen | TW06 | co-lecturer |
| Vounckx, Roger | VUB | co-lecturer |

| **Offered in the following programmes in 2026-2027** | **crdts** | **offering** |
|---|---|---|
| Bridging Programme Master of Science in Photonics Engineering | 4 | A |
| Master of Science in Electromechanical Engineering(main subject Control Engineering and Automation) | 4 | A |
| Master of Science in Electromechanical Engineering(main subject Electrical Power Engineering) | 4 | A |
| Master of Science in Electromechanical Engineering(main subject Maritime Engineering) | 4 | A |
| Master of Science in Electromechanical Engineering(main subject Mechanical Construction) | 4 | A |
| Master of Science in Electromechanical Engineering(main subject Mechanical Energy Engineering) | 4 | A |
| European Master of Science in Radiation and its Effects on Microelectronics and Photonics Technologies | 4 | A |
| Master of Science in Photonics Engineering | 4 | B |
| Master of Science in Photonics Engineering | 4 | A |

**Teaching languages**

English, Dutch

**Keywords**

technology, crystal growth, oxidation, photolithography, etching, diffusion, ion implantation, film deposition, photodetector, LED

**Position of the course**

This course describes the different processes involved in the fabrication of modern semiconductor components. The course is divided into two parts. The first part describes the physics of the different processing steps, while the second part describes the fabrication of the most important optical and optoelectronic components.

**Contents**

Crystal Growth

- Silicon Crystal Growth from the Melt: Starting Material, The Czochralski Technique, Distribution of Dopant, Effective Segregation Coefficient
- Silicon Float-Zone Process
- GaAs Crystal Growth Techniques: Starting Materials, Crystal Growth Techniques
- Material Characterization: Wafer Shaping, Crystal Characterization

Silicon Oxidation

- Thermal Oxidation Process: Kinetics of Growth, Thin Oxide Growth
- Impurity Redistribution During Oxidation
- Masking Properties of Silicon Dioxide
- Oxide Quality
- Oxide Thickness Characterization

Photolithography
- Optical Lithography: The Clean Room, Exposure Tools, Masks, Photoresist, Pattern Transfer, Resolution Enhancement Techniques
- Next-Generation Lithographic Methods: Electron Beam Lithography, Extreme Ultraviolet Lithography, X-Ray Lithography, Ion Beam Lithography, Comparison of Various Lithographic Methods

Etching
- Wet Chemical Etching: Silicon Etching, Silicon Dioxide Etching, Silicon Nitride and Polysilicon Etching, Aluminum Etching, Gallium Arsenide Etching
- Dry Etching: Plasma Fundamentals, Etch Mechanism, Plasma Diagnostics, and End-Point Control, Reactive Plasma Etching Techniques and Equipment, Reactive Plasma Etching Applications

Diffusion
- Basic Diffusion Process: Diffusion Equation, Diffusion Profiles, Evaluation of Diffused Layers
- Extrinsic Diffusion: Concentration-Dependent Diffusivity, Diffusion Profiles
- Lateral Diffusion

Ion Implantation
- Range of Implanted Ions: Ion Distribution, Ion Stopping, Ion Channeling
- Implant Damage and Annealing
- Implantation-Related Processes: Multiple Implantation and Masking, Tilt-Angle Ion Implantation, High-Energy and High-Current Implantation

Film Deposition
- Epitaxial Growth Techniques: Chemical Vapor Deposition, Molecular Beam Epitaxy
- Structures and Defects in Epitaxial Layers: Lattice-Matched and Strained-Layer Epitaxy, Defects in Epitaxial Layers
- Dielectric Deposition: Silicon Dioxide, Silicon Nitride, Low-Dielectric-Constant Materials, High-Dielectric-Constant Materials
- Polysilicon Deposition
- Metallization: Physical Vapor Deposition, Chemical Vapor Deposition, Aluminum Metallization, Copper Metallization, Silicide

Semiconductor Components
- Silicon Photodetectors
- Compound Semiconductor Photosensors
- Light Emitting Diodes

**Initial competences**

basic knowledge of physics and solid-state physics

**Final competences**

KNOWLEDGE and INSIGHTS:
- Understanding of different process steps like crystal growth, oxidation, photolithography, etching, diffusion, ion implantation, and film deposition;
- Understanding of the basic operation and the fabrication of the most important optical and optoelectronic components.

SKILLS:
- Basic use of TCAD tools for process modelling;
- Critical reading and understanding of a scientific article;
- Hands-on experience with a number of process steps in a clean room environment.

**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**

Lecture, Practical, Independent work

**Extra information on the teaching methods**

lectures; practicum, project.

**Study material**

None

**References**

- G.S. May and S.M. Sze. Fundamentals of Semiconductor Fabrication, John Wiley and Sons, 2004.
- H. Zimmermann. Silicon Optoelectronic Integrated Circuits, Springer, 2004.
- C.Y. Chang and S.M. Sze. ULSI Technology, McGraw-Hill, 1996.
- C.Y. Chang and S.M. Sze. ULSI Devices, John Wiley and Sons, 2000.

**Course content-related study coaching**

4 researchers

**Assessment moments**

end-of-term and continuous assessment

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

Oral assessment

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

Oral assessment

**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 closed-book exam complemented with oral examination;
During semester: graded project reports.

**Calculation of the examination mark**

Reports: 30%. examination: 70%