GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2025-2026

Processing and Packaging Technologies for Photonic Integration (E030450)

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

Credits 4.0 **Study time 120 h**

Course offerings in academic year 2026-2027

A (semester 2)	English	Gent

Lecturers in academic year 2026-2027

Van Steenberge, Geert	TW06	lecturer-in-charge
Missinne, Jeroen	TW06	co-lecturer

Offered in the following programmes in 2026-2027	**crdts**	**offering**
Master of Science in Silicon Photonics	4	A

Teaching languages

English

Keywords

Semiconductor technologies, packaging

Position of the course

Expose the students to various fabrication and packaging concepts necessary for PICs

Contents

Introduction
iSiPP50G Silicon Photonics Platform
Semiconductor Technologies
Crystal Growth
- Silicon Crystal Growth from the Melt
  - Starting Material

The Czochralski Technique
Distribution of Dopant
- Silicon float-zone process
- Material Characterization
  - Wafer Shaping

Crystal Characterization
Silicon Oxidation
- Thermal Oxidation Process
- 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
- Next-Generation Lithography Methods
  - Electron Beam Lithography

Extreme Ultraviolet Lithography

Etching
    Wet Chemical Etching
        Silicon Etching
Silicon Dioxide Etching
Silicon Nitride Etching
        Aluminum Etching
    Dry Etching
        Plasma Fundamentals
Etch Mechanism
Plasma Diagnostics
End-Point Control
Reactive Plasma Etching Applications
Diffusion
    Basic Diffusion Process
        Diffusion Equation
Diffusion Profiles
    Extrinsic Diffusion
Ion Implantation
    Range of Implanted Ions
        Ion Distribution
Ion Stopping
Ion Channeling
    Implant Damage and Annealing
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
    Metallization
        Physical Vapor Deposition
Chemical Vapor Deposition
Aluminum Metallization
        Copper Metallization
Fabrication of Silicon Waveguide Devices
Silicon-on-Insulator
    Separation by Implanted Oxygen (SIMOX)
    Bond and Etch-Back SOI
    Wafer Splitting
Selected Components from iSiPP50G Silicon Photonics Platform
    Silicon Waveguides
Modulators
Photodiodes
Grating couplers
Packaging Technologies
Optical Packaging
Fiber-Coupling
Grating-Coupling
Edge-Coupling
Fiber-Array Attach
V-groove Integration
Laser Integration
    Micro-Packaged Lasers
    Die Bonding
    Flip-Chip Bonding
    Transfer Printing
Micro-Optics Integration
    3D Nano-Printing
High-accuracy Pick-and-Place

Monolithic Micro-Optics Integration
Electrical Packaging
Wire Bonding
Flip-Chip Bumping and Bonding
Hybrid Bonding
Wafer-Level Packaging
2D Integration Using Organic Interposers
2.5D Integration Using Silicon Interposers with TSVs
3D Integration
Fanout Wafer-Level Packaging
Micro-Chiplets
Thermal Packaging
Thermal Interface Materials
Thermo-Electric Cooling

Initial competences

Basic optics and electromagnetics

Final competences

1 Understanding of different semiconductor process steps like crystal growth, oxidation, photolithography, etching, diffusion, ion implantation, and film deposition
2 Understanding of the fabrication of the most important integrated photonics components
3 Understanding of different photonics packaging processes like fiber array attach; laser integration, micro-optics integration, wire and flip-chip bonding, wafer-level packaging, thermal packaging.
4 Critical reading and understanding of a scientific article
5 Hands-on experience with a number of process steps in a clean room environment.
6 Development of a custom PIC package

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, cleanroom project, independent work

Study material

Type: Slides

Name: Slides and course notes used during the course
Indicative price: Free or paid by faculty
Optional: no
Additional information: Available electronically (free)

References

[1] May, Gary S.; Sze, Simon M. Fundamentals of Semiconductor Fabrication, John Wiley and Sons, 2004.
[2] C.Y. Chang and S.M. Sze. ULSI Technology, McGraw-Hill, 1996.
[3] C.Y. Chang and S.M. Sze. ULSI Devices, John Wiley and Sons, 2000.
[4] S.M. Sze. VLSI Technology, McGraw-Hill, 1988.
[5] H. Zimmermann. Silicon Optoelectronic Integrated Circuits, Springer, 2004.

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

Oral assessment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible in modified form

Extra information on the examination methods

- During examination period: oral closed-book assessment.
- During semester: periodic and permanent evaluation. Presentation about a project focusing on fabrication and packaging

Calculation of the examination mark

70% oral exam, 30% presentation.