GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Micro- and Nanotechnologies for Medical Device Design and Fabrication (E010600)

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

Credits 5.0 **Study time 140 h**

Course offerings and teaching methods in academic year 2024-2025

A (semester 2)	English	Gent	lecture
B (semester 2)	Dutch	Gent	

Lecturers in academic year 2024-2025

Op de Beeck, Maaike	TWO6	lecturer-in-charge
da Silva Gomes, Bruno	VUB	co-lecturer

Offered in the following programmes in 2024-2025	**crdts**	**offering**
Master of Science in Biomedical Engineering	5	B
Master of Science in Biomedical Engineering	5	A

Teaching languages

English, Dutch

Keywords

Biomedical devices, wearable technologies, implantable technologies and associated electronic components, embedded electronics, telemetry, IoT healthcare, microfabrication technologies, cleanroom, system integration.

Position of the course

The aim of the course is to give an in-depth overview of the micro-and nanotechnologies for biomedical devices and system design as well as an introduction to the micro-and nanofabrication techniques of biomedical devices and systems. It covers the embedded system design aspects, the biocompatibility and biostability aspects, as well as the system integration aspects. In the course several case studies of wearable and implantable medical devices at the level of embedded system design as well as fabrication technologies will be discussed.

Contents

1 Introduction
- Content
- Description of the course
- Evaluation

2 Functional blocks & requirements
- Sensors/actuators – interfacing – computational – memory - power - telemetry
- Biocompatibility and biostability of materials/devices (interaction body-foreign material, definition biocomp. & biostability, testing methods, MRI compatibility

3 Introduction to embedded systems
- Description
- Architectures
  1 Buses, protocols and interfaces
  2 Memories
  3 Computational technologies
- Analog, Digital en mixed-signal processing
- Features and limitations

4 Embedded systems for medical applications
- Specifications, categories
- Smart devices
- Off-the-shelf solutions

5 Communication en powering
  1 Wearable devices
    • Low-power wireless technologies
    • IoT Healthcare
    • Edge/Fog/ Cloud Computing strategies
    • Privacy and Security
  2 Implantable devices
    • Categories and specifications
    • Communication
    • Powering strategies
6 Case studies of embedded systems
  • Wearables: ECG, PPG
  • Implantables: Pacemaker, Insulin Pump
7 Fabrication technologies for electronic microsystems
  • Fabrication of chips, extrapolation to MEMS
  • Chip packaging, system integration
    • Si substrates
      • Si wafer fabrication
      • Si conductivity adjustment by doping and oxidation
    • Deposition of materials
      • PVD, CVD, ALD
    • Patterning of materials
      • lithography
      • wet etch, dry etch
    • Micro-fabrication of metal patterns
      • planarization
      • metal plating
    • Transfer of Si wafer to device
      • chip packaging
      • system integration
8 Cleanrooms, contamination control
9 Architecture and fabrication of wearable/implantable microdevices
  • Specific fabrication technologies
  • Flexible and stretchable system integration
  • Miniaturization of devices
  • Sterilization, sterile packaging
  • Regulatory aspects and risk analysis
10 Case studies of fabrication aspects
  • Neural probe for intra-fascicular implantation
  • Smart contact lens
  • Microfluidic system for DNA analysis

Initial competences

- General knowledge of biomaterials
- Principles of physiological systems
- Principles of electromagnetism
- Principles of electronic circuits and devices

Final competences

1 Understanding of the micro-and nanofabrication technologies for wearable and implantable biomedical devices and systems.
2 Skills to decide on the powering and the telemetry aspects of biomedical devices and systems.
3 Understanding of the contamination control in cleanroom environments.
4 Understanding the design constraints of the electronic and peripheral components of implantable devices.
5 System integration, sterilization and packaging aspects of biomedical devices and systems.
6 Design skills of the embedded system aspects.
7 knowledge of the basis priciples regarding regulatory aspects in order to introduce a new medical device on the market, including basis principles of required testing and related ethical aspects

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

Group work, Lecture, Independent work

Extra information on the teaching methods

lectures; on-line lectures; on-line knowledge-clips with plenary Q&A sessions; group work 1: regulatory aspects for medical systems; group work 2: virtual visit to clean room; group work 3: self-study of embedded biomedical system.

Study material

Type: Handouts

Name: handouts course part Bruno da Silva
Indicative price: € 14
Optional: yes
Language : English

Type: Handouts

Name: handouts course part Maaike Op de Beeck
Indicative price: € 14
Optional: no
Language : English

References

Scientific literature
Implantable Medical Electronics, Vinod Kumar Khanna

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

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

examination during the second examination period is not possible

Extra information on the examination methods

Permanent evaluation during semester:
- report on group work regarding working in cleanrooms (5%)
- report on group work regarding the movie 'The bleeding edge' and regarding section 8 of the course: safety and risk analysis of a biomedical system (5%)
- report on group work regarding the component assessment and design constraints of an embedded biomedical system (5%)

Periodic evaluation: oral examination comprising two parts:
- biocompatibility & biostability (section 2.2), communication & powering for implantable systems (section 5.2), fabrication aspects (section 7, 9, 10): open book, oral examination without preparation time
- all other topics except section 8: closed book oral examination with limited preparation time

Calculation of the examination mark

Periodic evaluatie (examen): 85%
Permanent evaluation: 15%