EE-517

Bio-nano-chip design

Carrara Sandro

Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Data and Internet of Things minor	H	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Neuro-X minor	H	Opt.
Neuro-X	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Introduction to heterogeneous integration for Nano-Bio-CMOS sensors on Chip. Understanding and designing of active Bio/CMOS interfaces powered by nanostructures.

Content

Currents and capacitive-effects in water solutions
Introduction to biological molecules
Thermodynamics of molecular Interactions
Nanotechnology for molecular assembly on chip surfaces
Nanotechnology to prevent electron transfer
Nanotechnology to enhance electron transfer
Chip design for electrochemical sensing: basic configurations
Chip design for biosensing with label-free capacitance mode (CBCM & FTCM Methods)
Chip design for biosensing in constant-bias (Current-to-Voltage & FTCC Methods)
Chip design for biosensing in voltage-scan (VDCM & DDSM Methods)

Keywords

OpAmp, CMOS, biosensors, carbon nanotubes, alkane/silane thiols, proteins, DNA

Learning Prerequisites

Recommended courses

Electronics I (BS course)
General chemistry OR Chemistry of surfaces (both BS courses)
Analysis IV (BS course)

Learning Outcomes

By the end of the course, the student must be able to:

- Choose bio materials
- Choose nano materials
- Judge an electrical interface
- Design complex analog circuits for electrochemical biosensing
- Design Bio-Nano-CMOS-sensing devices at system level
- Realize and discuss nanotechnology and molecular layers on chip Investigate
- Discuss biotechnology to Realize biosensors on chip

Teaching methods

Ex cathedra, exercises, and group-project with the help of Teaching Assistants

Expected student activities

Following the ex-cathedra lectures, active participation to the Q/A sessions organize during the ex-cathedra lectures, home work on lectures' slides as well as on the proposed excercies, work in class as well as at home on the group project.

Assessment methods

Written exam and group-project report

Resources

Bibliography

1. Course slides
2. Book: S.Carrara, **Bio/CMOS Interfaces and Co-Design**, Springer, NY, 2013
3. Book: S.Carrara, **Bio/CMOS Interfaces and Co-Design**, 2nd edition, Springer, NY, 2024

Ressources en bibliothèque

- Carrara, S., Bio/CMOS Interfaces and Co-Design, 2024 + 2013

Notes/Handbook

https://link.springer.com/book/10.1007/978-1-4614-4690-3 (1st Edition, 2013)
https://link.springer.com/book/10.1007/978-3-031-31832-0 (2nd Edition, 2024, 4 more chapters, and 5 more appendixes)

Websites

- https://www.epfl.ch/labs/bci/
- https://www.epfl.ch/labs/bci/student-projects/

Moodle Link

- https://go.epfl.ch/EE-517