MICRO-530

Nanotechnology

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Cursus	Sem.	Type
Microtechnics	MA2, MA4	Opt.
Minor in Quantum Science and Engineering	E	Opt.
Neuro-X minor	E	Opt.
Neuro-X	MA2, MA4	Opt.
Quantum Science and Engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	3 weekly
Number of positions	

Summary

This course gives the basics for understanding nanotechnology from an engineer's perspective: physical background, materials aspects and scaling laws, fabrication and imaging of nanoscale devices.

Content

Nanometer scale phenomena.
Basic understanding of some physical and chemical phenomena relevant at nanoscale.

- Basics of quantum mechanics
- Atomic structure (hydrogen like atoms)
- Molecular structure (linear combination of atomic orbitals)
- Band structure of solids in 0D, 1D, 2D, 3D (electrons in a box and in a periodic potential).
- Intermolecular forces
- Physi- and chemi-absorption
- Surface tension
- Examples of nanoscale phenomena: tunneling current, conductance quantization, Coulomb blockade, single electron transistor (SET), nanomagnetism, quantum Hall effect, Casimir effect.

Nanometer scale fabrication and imaging.
Overview of established and advanced methods to manufacturing nanopatterns and devices, as well as techniques to view nanoscale objects.

- Nanolithography for R&D prototyping (e.g. scanning probes, focused beam methods, stamp based replication, self-assembly)
- Nanolithography for industry (scalable projection lithography, nanoimprint lithography)
- Nanoscale imaging (optical methods, charged beam methods, scanning probe methods)

Keywords

- Nanotechnology
- quantum phenomena
- materials
- nanofabrication
- lithography
- fluidics
- self-assembly

• materials properties
• characterisation
• microscopy
• nanoprobes

Learning Prerequisites

Required courses

• Physics
• Basics of electromagnetism

Recommended courses

• Fundamentals of Microfabrication (MT 3rd year, or MOOC)
• Chemistry (basics)

Learning Outcomes

• Define the quantum physics origin of nanoscale effects
• Discriminate between different mechanisms influencing properties of nanomaterials and nanostructures and the involved length scales
• Describe the principal methods for nanomaterials synthesis
• Derive the principal nanofabrication techniques
• Derive interactions between nano-scale objects
• Synthesize the effects of quantum physics on nano-scale physicochemical properties
• Compare the different available methods for nanostructure characterisation & observation, as well as their advantages/disadvantages
• Propose a nanoimaging method and nanofabrication technique and process optimisations

Transversal skills

• Access and evaluate appropriate sources of information.
• Assess one's own level of skill acquisition, and plan their on-going learning goals.
• Use a work methodology appropriate to the task.

Teaching methods

Ex-cathedra course

Expected student activities

Actively participate during class in Q&A

Assessment methods

Oral exam

Supervision

Office hours	Yes

Assistants No
Forum Yes

Resources

Bibliography

Books
K. S. Krane, Modern Physics, John Wiley & Sons Inc, 2012.
P. Atkins, J. de Paula, Atkins' physical chemistry, Oxford Univ. Press, 2006.
J. N. Israelachvily, Intermolecular and surface forces, Academic Press, 2011.
Web resources
E. F. Schubert, Physical foundation of solid state devices,
http://homepages.rpi.edu/~schubert/

Ressources en bibliothèque

- Intermolecular and surface forces / Israelachvili
-
- Atkins' physical chemistry / Atkins, Paula
- Modern Physics / Krane

Notes/Handbook

Slides of the course available in Moodle:
https://go.epfl.ch/MICRO-530

Websites

- https://www.edx.org/course/micro-nanofabrication-mems-epflx-memsx-0

Moodle Link

- https://go.epfl.ch/MICRO-530