Universitat Autònoma de Barcelona

2019/2020

Nanomanufacturing

Code: 103306
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OB	4	1

Contact

Name: Francesc Torres Canals
Email: Francesc.Torres@uab.cat

Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Marta Fernandez Regulez
Sergi Claramunt Ruiz
Xavier Borrise Nogué

Prerequisites

It is recommended to have passed the subjects of the three previous courses, especially those related to the areas of physics, engineering and electronics.

Objectives and Contextualisation

The objective of the module is to present the techniques and methods that exist of manufacture at a micro and nanometric scale, so that the student will be capable of defining an appropriate sequence of processes for the realization of any type of device or functional structure. The content is focused on the manufacture of structures and functional devices, and not on the obtaining of materials. There will be practical and varied examples of fabrication of nanometric structures and devices (nanomechanical structures, graphene-based devices, nanosensors, photonic devices, micro / nano fluidic, etc.). An introduction to the operation and execution of processes will also be carried out in Clean Room.

Competences

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Be ethically committed.
- Communicate clearly in English.
- Communicate orally and in writing in ones own language.

- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.
- Lead and coordinate work groups.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Show motivation for quality.
- Show sensitivity for environmental issues.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. Adapt to new situations.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Be ethically committed.
4. Communicate clearly in English.
5. Communicate orally and in writing in ones own language.
6. Correctly characterise nanomanufacturing processes using the suitable techniques in each case.
7. Correctly handle the specific equipment used in nanomanufacturing processes.
8. Critically evaluate experimental results and deduce their meaning.
9. Describe the general aspects of nanoscale synthesis, manufacture and processing.
10. Describe the main technological processes of planar technology and the physical, technological and economic limits of miniaturisation.
11. Describe the principles of atomic and molecular manipulation.
12. Describe the processes of nanostructure growth and devices from nanometric elements (nanophylls, molecules, nanotubes,?) and with the use of templates.
13. Describe the self-assembly processes in the manufacture of functional nanostructures and devices: Copolymers blocks, molecular coupling, self-ordering of particles
14. Distinguish the different types of nanolithography: by electron and ion welding, nanoprinting, nanostenciling and local probe microscopy techniques.
15. Draft reports on the subject in English.
16. Follow correctly the safety protocols for laboratories with ambient controlled and white rooms.
17. Identify the situations in which the different methodologies studied can help to resolve problematic situations and know how to select the best techniques.
18. Lead and coordinate work groups.
19. Learn autonomously.
20. Manage the organisation and planning of tasks.
21. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
22. Operate with a certain degree of autonomy.
23. Perform bibliographic searches for scientific documents.
24. Perform nanomanufacture processes to obtain devices and systems on a nanoscale.
25. Present brief reports on the subject in English.
26. Propose creative ideas and solutions.

27. Propose suitable methods to characterise each of the processes used during nanomanufacture
28. Propose suitable nanomanufacture processes to obtain structures and devices on a nanoscale.
29. Reason in a critical manner
30. Recognise the correct terms for topics related to methodologies and experimentation in nanoscience and nanotechnology.
31. Resolve problems and make decisions.
32. Resolve problems with the help of the provided complementary bibliography.
33. Show motivation for quality.
34. Show sensitivity for environmental issues.
35. Specify the main characteristics of a white room.
36. Understand texts and bibliographies in English on each of the techniques, methodologies, tools and instruments in the subject area.
37. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

The subject is divided into four main blocks:

Module 1. Planar technology (10 h.T, 5 h.P)

The main processes of planar technology are described individually and the general aspects of micro / nano electronics technology are presented, as well as their evolution (miniaturization)

Introduction to planar technology: concept, waffers, sequence of processes, etc.
Individual technological processes: deposition (PVD and CVD), engravings (dry and wet), thermal processes, implantation, lithography.
Integration of processes, CMOS technology.
Evolution and limits of micro / nano electronics

Module 2. Nanolithography and "nanopatterning" (8 h.T, 4 h.P)

Lithography and nanopatronization techniques are described for the definition of nanostructures and nanodevices in surfaces. Examples of the current state of the art are presented.

Advanced optical lithography
Litrography by electron beam
Lithograph by ion beam
Nanoimprint lithography
Nanofabrication through SPMs
Other nanolithographies

Module 3 Nanofabrication "bottom-up" (6h.T)

We describe methods for performing nanostructures and devices based on a "bottom-up" approach, based on the assembly of individual nanometric elements to build structures and functional devices.

Self assembly and guided self assembly.
Structures and devices based on nanofiles and nanotubes
Structures and devices based on nanoparticles
DNA Origami
Other methods of chemical and electrochemical manufacturing

Module 4 Practical work on nanofabrication

The student is introduced to the principles of operation of a Clean Room and to the methodology of design of masks and micro-chips.

- Design of a mask with a dedicated software. (two sessions)

- Optical observation of the photolithography produced using the mask that the student has designed (one session).
- Characterization with electronic microscope of self-assembled polymers (one session).
- Visit to a Clean Room (one session).

In addition, 5 hours of seminars have been planned with researchers specializing in nanofabrication.

Methodology

Teaching will consist on 24 hours of theory lectures, 9 hours of problems and 15 hours of laboratory practices. In addition, 5 hours of seminar sessions are reserved to complete any aspect of the subject.

Practices: The practical sessions and their corresponding reports will be carried out in groups of a maximum of three students. Groups formed by more than three students will not be accepted. The delivery of the reports will be governed by a deadline that will be communicated after having done the practice, via virtual campus.

Extra exercises: During the course, extra exercises may be given to the students that must be done out of the teaching hours and which will be evaluable.

Seminars: During the course there will be a maximum of five seminars given by researchers working in the field of micro and nanofabrication, aimed at presenting to the student the world of research, beyond the academic vision that is given to the course. Attendance to this seminar is obligatory to be able to be evaluated of the whole course.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Exercices	9	0.36	2, 8, 33, 17, 22, 27, 29, 30, 32, 31, 37
Laboratory	15	0.6	2, 8, 6, 36, 4, 5, 33, 11, 13, 12, 14, 25, 23, 20, 17, 18, 7, 3, 34, 27, 28, 24, 15, 16, 37
Seminars	5	0.2	2, 19, 8, 5, 25, 23, 17, 18, 26, 29, 30
Theory	24	0.96	9, 10, 11, 13, 12, 14, 35
Type: Autonomous			
Delivery of exercises and tests	32	1.28	19, 8, 5, 11, 13, 12, 14, 20, 22, 26, 30, 31
Reading of the class notes	30	1.2	19, 3, 21, 22
Reading of the guides of practices of laboratory	9	0.36	19, 36, 25, 23, 20, 17, 21, 22, 29, 30, 15

Assessment

There will be the following evaluation activities:

Two partial exams (theory and problems), one at the mid-term and the other at the end, with a weight under the final qualification of 70% (35% each). Attendance to these partial exams is mandatory to be able to access to the recovery exam.

Reports corresponding to laboratory practices, with a weight on the final qualification of 25%. This note will be taken into account for the final evaluation provided that the student exceeds the qualification of 4.5 as an average of the two partials or as a qualification of the recovery exam.

NOTE: Attendance at the practical sessions and the delivery of the corresponding report are an indispensable condition for the student to be evaluated in this subject.

Exercises about theoretical classes and seminar work: with a weight on the final qualification of 5%

NOTE: Attendance at the seminars is mandatory for the student to be evaluated in this subject.

Exam (theory and problems) for recovery: Attendance to the recovery exam will be recommended if you have obtained a qualification of less than 5 in one of the two partial examinations. The contents referring to the first partial and the second will be assessed separately. This allows presentation to the recovery of a partial or total contents of the subject. Final qualification of the exams (70% of the final subject qualification) will be the averaging between the two parts of the subject, choosing for each part the best qualification between the partial exam and the recovery exam.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Laboratory reports	25%	10	0.4	1, 19, 36, 4, 33, 35, 25, 23, 20, 18, 34, 21, 22, 26, 29, 30, 15, 32, 31, 37
Partial exams	70%	6	0.24	5, 9, 10, 11, 13, 12, 14, 35, 17, 27, 28, 30, 31
continuous evaluation, exercises, seminars	5%	10	0.4	1, 2, 19, 8, 6, 36, 4, 5, 33, 9, 10, 11, 13, 12, 35, 25, 23, 20, 18, 7, 3, 34, 21, 22, 26, 29, 24, 30, 15, 16, 37

Bibliography

Designing network on-chip architectures in the nanoscale era / edited by José Flich, Davide Bertozzi; Boca Raton : Chapman & Hall/CRC, cop. 2011

Nuevas Tecnologías en los Dispositivos Electrónicos / A. Godoy et. al: Departamento de Electrónica y Tecnología de Computadores, Universidad de Granada, ISBN: 978-84-691-4090-1, 2008.

Nanotechnology : an introduction to nanostructuring techniques / Michael Köhler, Wolfgang Fritzsche 2nd ed.Weinheim : Wiley-VCH, cop. 2007

Fundamentals of microfabrication and nanotechnology / Marc J. Madou; Boca Raton, FL Taylor & Francis, 2011

Articles published in research journals. The professors will provide the appropriate information.