Teaching Guide					
Identifying Data					2023/24
Subject (*)	Nanofabrication			Code	610G04040
Study programme	Grao en Nanociencia e Nanotecnoloxía				
Descriptors					
Cycle	Period	Year		Type	Credits
Graduate	2nd four-month period	Fourth		Obligatory	6
Language	Spanish				
Teaching method	Face-to-face				
Prerequisites					
Department	Química				
Coordinador	Gómez Pérez, Jennifer		E-mail	i.jennifer.gomez@udc.es	
Lecturers	Criado Fernández, Alejandro Gómez Pérez, Jennifer		E-mail	a.criado@udc.es i.jennifer.gomez@udc.es	
Web					
General description	Students will be introduced to micro- and nano-scale fabrication techniques and methods, as well as unconventional methods for creating nanostructures and surface functionalization. In addition, students will be introduced to the operation and processes of the cleanroom. Theory will be combined with practical examples and active participation will be encouraged. Upon completion, students will have a solid foundation in nanofabrication techniques to address technological challenges and contribute to scientific advancement in the fabrication of devices and structures at the micro and nanometer scale.				

Study programme competences / results	
Code	Study programme competences / results
A4	CE4 - Desarrollar trabajos de síntesis y preparación, caracterización y estudio de las propiedades de materiales en la nanoescala.
A5	CE5 - Conocer los rasgos estructurales de los nanomateriales, incluyendo las principales técnicas para su identificación y caracterización
A6	CE6 - Manipular instrumentación y material propios de laboratorios para ensayos físicos, químicos y biológicos en el estudio y análisis de fenómenos en la nanoescala.
A7	CE7 - Interpretar los datos obtenidos mediante medidas experimentales y simulaciones, incluyendo el uso de herramientas informáticas, identificar su significado y relacionarlos con las teorías químicas, físicas o biológicas apropiadas.
A8	CE8 - Aplicar las normas generales de seguridad y funcionamiento de un laboratorio y las normativas específicas para la manipulación de la instrumentación y de los productos y nanomateriales.
A9	CE9 - Evaluar correctamente los riesgos sanitarios y de impacto ambiental asociados a la Nanociencia y la Nanotecnología.
B2	CB2 - Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio
B3	CB3 - Que los estudiantes tengan la capacidad de reunir e interpretar datos relevantes (normalmente dentro de su área de estudio) para emitir juicios que incluyan una reflexión sobre temas relevantes de índole social, científica o ética
B5	CB5 - Que los estudiantes hayan desarrollado aquellas habilidades de aprendizaje necesarias para emprender estudios posteriores con un alto grado de autonomía
B7	CG2 - Resolver problemas de forma efectiva.
B8	CG3 - Aplicar un pensamiento crítico, lógico y creativo.
B9	CG4 - Trabajar de forma autónoma con iniciativa.
B10	CG5 - Trabajar de forma colaborativa.
B12	CG7 - Comunicarse de manera efectiva en un entorno de trabajo.
C2	CT2 - Dominar la expresión y la comprensión de forma oral y escrita de un idioma extranjero
C3	CT3 - Utilizar las herramientas básicas de las tecnologías de la información y las comunicaciones (TIC) necesarias para el ejercicio de su profesión y para el aprendizaje a lo largo de su vida
C5	CT5 - Entender la importancia de la cultura emprendedora y conocer los medios al alcance de las personas emprendedoras

C7	CT7 - Desarrollar la capacidad de trabajar en equipos interdisciplinares o transdisciplinares, para ofrecer propuestas que contribuyan a un desarrollo sostenible ambiental, económico, político y social.
C8	CT8 - Valorar la importancia que tiene la investigación, la innovación y el desarrollo tecnológico en el avance socioeconómico y cultural de la sociedad

Learning outcomes			
Learning outcomes	Study programme competences / results		
Recognizing the protocols for handling instruments, reagents, and chemical waste in nanoscience and nanotechnology laboratories.	A4 A6 A8 A9	B2 B3 B5 B8	C3 C8
Knowing and complying with safety protocols in laboratories with controlled environments and cleanrooms.	A6 A8 A9	B5 B12	C3 C8
Being able to simulate simple procedures in laboratories with controlled environments.	A6 A8 A9	B5 B8	C5 C7
Being able to perform nanofabrication processes for the production of devices and systems at the nanoscale.	A4 A6 A8	B3 B9 B10	C7 C8
Properly using techniques for surface functionalization and characterization in the field of nanoscience and nanotechnology.	A4 A5 A6 A7 A8	B7 B8 B9 B10	C2 C3 C7 C8

Contents	
Topic	Sub-topic
Introduction to nanofabrication	Basic fundamentals of nanofabrication
Techniques and technologies for processing nanomaterials	Diffusion, oxidation, lithography, chemical vapor deposition, physical vapor deposition, chemical etching, and metallization
Simple procedures in cleanrooms	Cleaning and gowning protocols, access control and security, sample and material handling procedures
Unconventional methods for nanostructure fabrication	Chemical functionalization for nanofabrication
Manufacturing of nanodevices	Design, fabrication, characterization, and testing of nanodevices -Assessment of risks associated with the experiment and their prevention -Experimental procedure for synthesis, fabrication, and/or functionalization -Selection and/or handling of characterization and testing techniques -Data interpretation -Laboratory notebook preparation and final report presentation

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A5 B5 B8 C2 C8	10	20	30
Laboratory practice	A4 A5 A6 A7 A8 A9 B3 B7 B8 B9 B10 C3 C7 C8	40	24	64

Field trip	A8 B8 B12 C5 C8	4	2	6
Summary	A7 B2 B3 B8 B9 C3	0	18	18
Supervised projects	A5 A7 B3 B5 B8 B9 C3 C8	3	10	13
Mixed objective/subjective test	A5 A7 A9 B2 B3 B7 B8 C2 C3	3	15	18
Personalized attention		1	0	1
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	**Description**
Guest lecture / keynote speech	Pre-laboratory sessions. They serve to introduce the fundamentals of nanofabrication and functionalization techniques. The topics of the subject will be taught by the professors with the help of audiovisual means. The relevant documentation will be made available to the students on the Virtual Campus.
Laboratory practice	Simulation of nanofabrication processes using specialized software. Laboratory work on fabrication techniques, substrate functionalization, and characterization, which complements the knowledge imparted in the lecture session. These activities are carried out under the guidance and supervision of the Professor.
Field trip	Visit to a controlled environment or cleanroom nanofabrication center. *If not possible, complementary laboratory practices will be conducted for the hours allocated for the field trip.
Summary	After the laboratory work, a laboratory notebook and report for each practice will be completed. They will be individually submitted at the end of the practices and will be corrected and evaluated.
Supervised projects	Final activity reflecting theoretical and methodological domain of the subject.
Mixed objective/subjective test	Mixed assessment used for evaluating learning.

Personalized attention	
Methodologies	**Description**
Laboratory practice Supervised projects	Personalized and focused tutoring will be provided to students to address their doubts and clarifications. This individualized attention will be carried out throughout the course upon prior request from the students.

Assessment			
Methodologies	**Competencies / Results**	**Description**	**Qualification**
Laboratory practice	A4 A5 A6 A7 A8 A9 B3 B7 B8 B9 B10 C3 C7 C8	The experimental work during laboratory sessions will be evaluated, including planning, organization, skill, safety, and results.	15
Mixed objective/subjective test	A5 A7 A9 B2 B3 B7 B8 C2 C3	Evaluation of theoretical knowledge (tests, problems, questions).	40
Supervised projects	A5 A7 B3 B5 B8 B9 C3 C8	The individual presentation and group discussion of the work carried out in the laboratory practices	25
Summary	A7 B2 B3 B8 B9 C3	The laboratory notebook and reports for each of the conducted practices will be evaluated.	20

Assessment comments

Laboratory practices are mandatory. Absence from practices must be duly justified in order to pass the course.First opportunity: To pass the subject, a minimum of 5 points out of 10 is required (in total). A minimum of 4 out of 10 points is required in each of the evaluable parts to pass the subject (if this minimum is not reached in any of the parts, the overall grade will be a fail, with the numerical score achieved, up to a maximum of 4.5). If the in-person work of laboratory practices is started, the evaluation process is considered initiated, and the grade cannot be "not submitted".Second opportunity: To pass the subject, a minimum of 5 points out of 10 must be achieved. The same evaluation criteria will be maintained, and only one new mixed test will be carried out. It is necessary to have completed the "Laboratory Practices" during the course to be able to recover the subject in the second opportunity.In the completion of the course work, plagiarism and the use of non-original material, including material obtained from the internet without explicit indication of its source and, if applicable, permission from its author, will be graded as a failure (0.0) in the activity. If during an exam a student engages in copying, this will result in a failure (0.0) for the course in the corresponding examination period. Once fraudulent completion of tests or evaluation activities is confirmed, it will directly result in a failing grade "0" for the course in the corresponding opportunity.Grading systems: Numeric from 0 to 10, with 10 being the maximum grade and 5 the passing grade. The grading system will be expressed as a numeric grade in accordance with the provisions of Article 5 of Royal Decree 1125/2003 of September 5 (Official State Gazette of September 18), which establishes the European credit transfer and accumulation system and the grading system in official university qualifications with validity throughout the national territory. Grading system: 0-4.9 = Fail, 5-6.9 = Pass, 7-8.9 = Good, 9-10 = Excellent, 9-10 = Honors (Exceptional).Honors will be awarded preferably to students who achieve a grade equal to or higher than 9 in the first opportunity.For part-time students, both in the first and second opportunities: The Experimental Part (Laboratory Practices, Summary, Supervised Projects, and Mixed Assessment) is mandatory and counts the same as for full-time students. They may have flexibility in the deadline for submission of assignments. They are exempt from attending lectures.In successive academic years: The teaching-learning process (including evaluation) refers to one academic year and, therefore, starts again with a new academic year, including all activities and evaluation procedures scheduled for the new academic year.In this course, the general criteria of the UDC will be applied, in its commitment to respect environmental values and gender perspective.

Sources of information	
Basic	-Nanofabrication: Principles, Capabilities and Limits. Springer 2017 -Nanofabrication: Techniques and Principles. Springer, 2012 -Nanofabrication: Nanolithography techniques and their applications. IOP, 2020 -Research articles published in scientific journals. Professors will provide the appropriate information.-Nanofabrication: Principles, Capabilities and Limits. Springer 2017-Nanofabrication: Techniques and Principles. Springer, 2012-Nanofabrication: Nanolithography techniques and their applications. IOP, 2020-Research articles published in scientific journals. Professors will provide the appropriate information.
Complementary	-Micro and Nano Fabrication: Tools and Processes. Springer, 2015 -Nanotechnology: principles and practices. Springer, 2015 -Nanomaterials: an introduction to synthesis, properties and applications. Wiley, 2013 -Cleanroom Technology: Fundamentals of Design, Testing and Operation. Wiley, 2010 -Functionalization of Semiconductor Surfaces. Wiley, 2012-Micro and Nano Fabrication: Tools and Processes. Springer, 2015-Nanotechnology: principles and practices. Springer, 2015-Nanomaterials: an introduction to synthesis, properties and applications. Wiley, 2013-Cleanroom Technology: Fundamentals of Design, Testing and Operation. Wiley, 2010-Functionalization of Semiconductor Surfaces. Wiley, 2012

Recommendations
Subjects that it is recommended to have taken before
Techniques of Characterisation of Nanomaterials 2/610G04030
Techniques of Characterisation of Nanomaterials 1/610G04025
Synthesis and Preparation of Nanomaterials/610G04020
Surface Science/610G04021
Organic Reactivity /610G04012
Instrumental Analysis/610G04014
Chemistry of the Elements/610G04011
Integrated Basic Laboratory/610G04004
Subjects that are recommended to be taken simultaneously

Subjects that continue the syllabus
Other comments
To ensure safety conditions in the laboratory, during the course, a "laboratory notebook" will be used, preferably in physical format. However, the submission of assignments can be done in electronic format.Recommendations for Sustainability, Environment, Individual, and Gender Equality.To contribute to a sustainable immediate environment and fulfill the objective of Action number 5: "Healthy and environmentally and socially sustainable teaching and research" of the "Green Campus Action Plan of the Faculty of Sciences," the following measures will be implemented:1.- The submission of documentary assignments for this course will be done through Moodle, in digital format without the need for printing.2.- The importance of ethical principles related to sustainability values in personal and professional behavior should be considered.3.- Full integration of students who may face physical, sensory, psychological, or sociocultural difficulties in accessing university life will be facilitated, ensuring equal and beneficial opportunities.4.- Efforts will be made to identify and modify sexist biases and attitudes, influencing the environment to promote respect and equality. In case adverse situations related to gender are identified, measures will be taken to address and correct them.5.- It is expected that university students have acquired the necessary linguistic skills for oral and written expression. Therefore, spelling (including orthography, accentuation, and punctuation), grammar, and vocabulary will be crucial and mandatory for successfully completing assignments and exams in this course.