



POLITÉCNICA

INTERNATIONAL
CAMPUS OF
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COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros de
Telecomunicacion

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93001303 - Photovoltaic And Optoelectronic Fabrication Technology

DEGREE PROGRAMME

09BP - Master Universitario En Energia Solar Fotovoltaica

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

Index

Learning guide

1. Description.....	1
2. Faculty.....	1
3. Prior knowledge recommended to take the subject.....	2
4. Skills and learning outcomes	2
5. Brief description of the subject and syllabus.....	4
6. Schedule.....	5
7. Activities and assessment criteria.....	7
8. Teaching resources.....	9
9. Other information.....	10

1. Description

1.1. Subject details

Name of the subject	93001303 - Photovoltaic And Optoelectronic Fabrication Technology
No of credits	5 ECTS
Type	Optional
Academic year of the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09BP - Master Universitario en Energia Solar Fotovoltaica
Centre	09 - Escuela Tecnica Superior De Ingenieros De Telecomunicacion
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Ivan Garcia Vara	IES-204	ivan.garciav@upm.es	Sin horario.
Carlos Del Cañizo Nadal (Subject coordinator)	IES-113-1	carlos.canizo@upm.es	Sin horario.
David Fuertes Marron	IES-201	david.fuertes@upm.es	Sin horario.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Fundamentals of physics and knowledge about semiconductor physics

4. Skills and learning outcomes *

4.1. Skills to be learned

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CE1 - Comprender, analizar y juzgar la relevancia de cualquier contribución en este campo, en relación con su entorno social, energético y científico-técnico.

CE3 - Realización, desarrollo e innovación de procesos tecnológicos para la fabricación de dispositivos fotovoltaicos.

CG5 - Gestión de la información: buscar y gestionar recursos bibliográficos adecuados con eficiencia, aprender a continuar los estudios de manera ampliamente autónoma como base para la futura actividad de investigación e innovación

CG7 - Trabajo en contextos internacionales: Llevar a cabo un proceso sustancial de investigación con seriedad e integridad académicas, integrado en un grupo de I+D+i con proyección internacional

CG8 - Aplicar metodologías, procedimientos, herramientas y normas del estado del arte para la creación de nuevos componentes tecnológicos; Construir nuevas hipótesis y modelos, evaluarlos y aplicarlos a la resolución de problemas

CG9 - Comunicar juicios, y conocimientos a audiencias especializadas y no especializadas, de una manera razonada, clara y sin ambigüedades

CT3 - Uso de la lengua inglesa: comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa; redactar en inglés informes y artículos científico-técnicos usando herramientas informáticas; realizar exposiciones públicas en inglés de trabajos, resultados y conclusiones de investigación, por ejemplo, en las asignaturas del Máster o en congresos de carácter mayoritariamente internacional o en estancias en centros extranjeros, todo ello con la ayuda de medios informáticos audiovisuales

4.2. Learning outcomes

RA15 - RA5 - Relacionar los principios básicos con los aspectos prácticos

RA18 - RA15 - Formación en técnicas de cálculo de costes

RA4 - RA2 ? RA24 ? Conocimiento de los fundamentos físicos de las células solares

RA23 - RA71 - Familiarizarse con los aspectos prácticos de fabricación de dispositivos fotovoltaicos

RA20 - RA46 - Adiestrar al alumno en el trabajo en equipo

RA22 - RA70 - Conocer los procesos de fabricación de células solares

RA14 - RA4 - Capacidad para analizar los resultados

RA7 - RA6 ? RA25 ? Capacidad para comprender el funcionamiento básico de diferentes tipos de células solares, tanto actuales, como las que surjan en un futuro próximo.

RA19 - RA45 - Capacitar al alumno a hacer presentaciones en público

RA21 - RA47 - Aprender a argumentar convincentemente

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Study of manufacturing technologies for photovoltaic solar cells and modules.

Manufacturing processes for silicon solar cells, including chemical steps, diffusion, film deposition.

Manufacturing technologies for thin films and for solar cells based on III-V semiconductors.

5.2. Syllabus

1. Introduction to solar cell manufacturing
2. Manufacturing technologies for silicon solar cells
3. Manufacturing technologies for thin film solar cells
4. Manufacturing technologies for solar cells based on III-V semiconductors
5. Manufacturing costs
6. Lab sessions on the manufacturing of solar cells

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	Introduction Duration: 02:00	Basic characterization of solar cells Duration: 02:00		
2	Si technology: diffusion Duration: 02:00	Optimizing a PV factory plant Duration: 02:00		
3	Si technology: layer deposition Duration: 02:00	Lab session: texturing Duration: 02:00		
4	Si technology showroom Duration: 02:00	Lab session: diffusion Duration: 02:00		
5	Manufacturing costs Duration: 02:00	Simulation of Manufacturing costs Duration: 02:00		
6	Thin film technology I Duration: 02:00	Lab session: lifetime measurements Duration: 02:00		
7	Thin film technology II Duration: 02:00	Lab session: photolithography Duration: 02:00		
8	Thin film technology III Duration: 02:00	Lab session: metallisation Duration: 02:00		
9	Technology of III-V semiconductors I Duration: 02:00	Lab session: SiNx deposition Duration: 02:00		
10	Technology of III-V semiconductors II Duration: 02:00			Assistance to lab sessions Continuous assessment Presential Duration: 00:01
11	Exercises about solar cell manufacturing technologies Duration: 04:00			
12				Presentation of project Continuous assessment and final examination Presential Duration: 04:00

13				
14				
15				
16				
17				<p>Exam</p> <p>Continuous assessment and final examination Presential Duration: 03:00</p> <p>Exam about lab processes</p> <p>Final examination Presential Duration: 01:00</p>

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Assistance to lab sessions		Face-to-face	00:01	20%	3 / 10	CG8 CB6 CG9 CB7 CB10 CE3 CT3 CB8
12	Presentation of project		Face-to-face	04:00	30%	3 / 10	CB6 CG5 CG7 CG9 CB7 CB10 CE1 CE3 CT3 CB8
17	Exam		Face-to-face	03:00	50%	3 / 10	CE3 CT3 CB8 CB7 CB10

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
12	Presentation of project		Face-to-face	04:00	30%	3 / 10	CB6 CG5 CG7 CG9 CB7 CB10 CE1 CE3 CT3 CB8

17	Exam		Face-to-face	03:00	50%	3 / 10	CE3 CT3 CB8 CB7 CB10
17	Exam about lab processes		Face-to-face	01:00	20%	3 / 10	CG8 CB6 CB7 CB10 CE1 CE3 CT3 CB8

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Presentation of project		Face-to-face	04:00	30%	3 / 10	CG5 CG7 CG8 CB6 CG9 CB7 CB10 CE1 CT3 CB8
Exam		Face-to-face	03:00	50%	3 / 10	CB7 CB10 CE3 CT3 CB8
Exam about lab processes		Face-to-face	01:00	20%	3 / 10	CB6 CB7 CB10 CE1 CE3 CT3 CB8

7.2. Assessment criteria

1. Presenting the team project on the design of a manufacturing line is compulsory.
2. Assisting to the lab sessions is compulsory.
3. Doing the written exam is compulsory

The final grade should be equal or above 5/10, when considering each of the evaluation activities and their weight, to pass successfully this course.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Manufacturing lab	Equipment	Manufacturing equipment for silicon solar cells of the Solar Energy Institute
Characterization lab	Equipment	Equipment for the characterization of photovoltaic materials and devices
Moodle	Web resource	Repository for documentation, student forum and marks
References	Bibliography	Recommended books and scientific papers
Simulation software	Others	Access to software tools related to Photovoltaic Manufacturing

9. Other information

9.1. Other information about the subject

Some of the lab sessions will take place in the facilities that the Instituto de Energía Solar has in the UPM Park in TecnoGetafe.

The goals and content of this course are aligned with the Sustainable Development Goals (SDG), as is in fact the whole Master on Photovoltaic Solar Energy to which it belongs. The promotion of Photovoltaic Solar Energy, which is becoming a cornerstone in the energy transition we are experiencing, has a clear positive impact in SDG 7 (Affordable and Clean Energy) and in SDG13 (Climate action).

Paying special attention to manufacturing processes, it also tackles some of the concerns included in SDG 9 (Industries, Innovation and Infrastructures), addressing sustainability aspects of the industrial processes and highlighting the importance of innovative manufacturing processes in the photovoltaic sector.