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

2023/24 - Semester 1

Index

Learning guide

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 ot 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	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Carlos Del Cañizo Nadal (Subject coordinator)	IES-113-1	carlos.canizo@upm.es	Sin horario.
Ivan Garcia Vara	IES-204	ivan.garciav@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 contribuciÃ³n en este campo, en relaciÃ³n con su entorno social, energÃ©tico y cientÃfico-tÃ©cnico.

CE3 - RealizaciÃ³n, desarrollo e innovaciÃ³n de procesos tecnolÃ³gicos para la fabricaciÃ³n de dispositivos fotovoltaicos.

CG5 - GestiÃ³n de la informaciÃ³n: buscar y gestionar recursos bibliogrÃ¡ficos adecuados con eficiencia, aprender a continuar los estudios de manera ampliamente autÃ³noma como base para la futura actividad de investigaciÃ³n e innovaciÃ³n

CG7 - Trabajo en contextos internacionales: Llevar a cabo un proceso sustancial de investigaciÃ³n con seriedad e integridad acadÃ©micas, integrado en un grupo de I+D+i con proyecciÃ³n internacional

CG8 - Aplicar metodologÃas, procedimientos, herramientas y normas del estado del arte para la creaciÃ³n de nuevos componentes tecnolÃ³gicos; Construir nuevas hipÃ³tesis y modelos, evaluarlos y aplicarlos a la resoluciÃ³n de problemas

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

CT3 - Uso de la lengua inglesa: comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa; redactar en inglÃ©s informes y artÃculos cientÃfico-tÃ©cnicos usando herramientas informÃ¡ticas; realizar exposiciones pÃºblicas en inglÃ©s de trabajos, resultados y conclusiones de investigaciÃ³n, por ejemplo, en las asignaturas del MÃ¡ster o en congresos de carÃ¡cter mayoritariamente internacional o en estancias en centros extranjeros, todo ello con la ayuda de medios informÃ¡ticos audiovisuales

4.2. Learning outcomes

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

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

RA18 - RA15 - Formación en técnicas de cálculo de costes

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

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

RA21 - RA47 - Aprender a argumentar convincentemente

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

* 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		**Lab practice** Continuous assessment Presential Duration: 00:15
4	**Si technology showroom** Duration: 02:00	**Lab session: diffusion** Duration: 02:00		**Lab practice** Continuous assessment Presential Duration: 00:15
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		**Lab practice** Continuous assessment Presential Duration: 00:15
7	**Thin film technology II** Duration: 02:00	**Lab session: photolitography** Duration: 02:00		
8	**Thin film technology III** Duration: 02:00	**Lab session: metallisation** Duration: 02:00		**Lab practice** Continuous assessment Presential Duration: 00:15
9	**Technology of III-V semiconductors I** Duration: 02:00	**Lab session: SiNx deposition** Duration: 02:00		**Lab practice** Continuous assessment Presential Duration: 00:15
10	**Technology of III-V semiconductors II** Duration: 02:00			
11	**Exercises about solar cell manufacturing technologies** Duration: 04:00			

12				**Presentation of project** Continuous assessment Presential Duration: 04:00
13				
14				
15				
16				
17				**Exam** Continuous assessment and final examination Presential Duration: 03:00

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
3	Lab practice		Face-to-face	00:15	4%	/ 10	CB6 CB7 CB8 CB10 CG8 CG9 CT3 CE3
4	Lab practice		Face-to-face	00:15	4%	/ 10	CB6 CB7 CB8 CB10 CG8 CG9 CT3 CE3
6	Lab practice		Face-to-face	00:15	4%	/ 10	CB6 CB7 CB8 CB10 CG8 CG9 CT3 CE3
8	Lab practice		Face-to-face	00:15	4%	/ 10	CB6 CB7 CB8 CB10 CG8 CG9 CT3 CE3
9	Lab practice		Face-to-face	00:15	4%	/ 10	CB6 CB7 CB8 CB10 CG8 CG9 CT3

							CE3
12	Presentation of project		Face-to-face	04:00	25%	/ 10	CB6 CB7 CB8 CB10 CG5 CG7 CG8 CG9 CT3 CE1
17	Exam		Face-to-face	03:00	55%	3 / 10	CB7 CB8 CB10 CT3 CE3

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Exam		Face-to-face	03:00	55%	3 / 10	CB7 CB8 CB10 CT3 CE3

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Exam		Face-to-face	03:00	55%	3 / 10	CB7 CB8 CB10 CT3 CE3
Exam about lab processes		Face-to-face	01:00	20%	/ 10	CB6 CB7 CB8 CB10 CT3 CE1 CE3

Presentation of project		Face-to-face	02:00	25%	/ 10	CB6 CB7 CB8 CB10 CG5 CG7 CG8 CG9 CT3 CE1

7.2. Assessment criteria

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

The lab practices and the presentation of the project for the progressive evaluation are liberating blocks with regards to the extraordinary evaluation.

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.