



**1. Code:** 35476 **Name:** Photonic integrated circuits

**2. Credits:** 6,00 **–Lecture:** 3,00 **–Practice:** 3,00 **Type of Course:** Compulsory  
**Degree:** 2314-Master's Degree in Telecommunication Engineering  
**Module:** 1-Telecommunication Technologies Module **Subject:** 1-Telecommunication and Multimedia Systems  
**University Center:** SCHOOL OF TELECOMMUNICATIONS ENGINEERING

**3. Coordinator:** Muñoz Muñoz, Pascual  
**Departament:** COMMUNICATIONS

#### 4. References

#### 5. Course Outline

##### Course objectives

The course will educate students in the technology and business aspects of photonic integrated circuits.

##### Contextualization of the course

Several market reports support the statement the topics addressed in this course are of growing interest for the industry. For instance, the market report by TransparencyMarketResearch [1] states "The photonic integrated circuit market is growing at a phenomenal rate due to the significant improvements in power consumption, system size, reliability, and cost. The development in silicon photonic technology has helped in enabling large scale manufacturing of PIC products at low cost. Also, most players are developing monolithically integrated InP (Indium Phosphide) based photonic integrated circuits that can integrate more than 600 components in a single chip. Thus, there is increasing competition as players are trying to produce PIC based products at low cost."

Regarding localization of the industries where the young graduates may find a position, the report highlights "Currently, North America is the largest market for PIC based products owing to the increasing applications of optical fibers in datacenters and WAN. North America holds more than 40% share of the overall PIC market; however, Asia-Pacific is expected to emerge as a market leader in the coming years growing at a CAGR of about 35% due to the prolific growth in datacenters and access network in the region. Europe ranks second in the market for PIC products. Currently, Asia-Pacific is the largest player in access network applications of optical fiber communication."

On the other hand, the market report by Yole Development [2] states "For several years now, the silicon photonics projects have been under the umbrella of large-scale R&D projects to set up roadmaps. Today, Multi-Project Wafer services foundries are opening and more industrial foundry activities are set up. Generic technologies and generic production platforms are needed to achieve low cost/high volume. As the future lays in the separation of design and fabrication, this industry is looking for an electronics-like foundry model." and regarding the evolution of the market "Although the market will grow by a factor of 3 in 5 years, business could explode after 2020 as inter and intra-chip communications could make this market grow by a factor of 10!".

In the reports, the following companies and organizations are listed as key players: Altera, Altis, AML, Apple, Aurrion, Avago, BAE Systems, Calipia, CEA Leti, Chiral Photonics, Cisco, ColorChip, Cyoptics/InPlane, DAS Photonics, Effect Photonics, Enablence, ePIXfab, EuroPIC, EVgroup, Fraunhofer hhl, Freescale, ghent University, IHP, Microelectronics, Fujitsu, Genalyte, Helios, HP Labs, IBM, IME (A\*STAR), IMEC, Infinera, Intel, IPKISS, JePPIX, Kotura, Cisco/, LightWire, LioniX, Luxtera, MIT, Mitsubishi heavy Industries, Molex, NeoPhotonics, Northrop grumman, NTT, Nvidia, Oclaro, OneChip, Photonics, OPSIS SYSTEM, Oracle, PECST, Photline, Sandia, Skorpis Technologies, STM, Sun, SUSS MicroTec, TEEM Photonics, TI, TSMC, U2t photonics, UCSB, Stanford University, VLC Photonics, Xilinx, XIO Photonics.

The course addresses not only technical and innovative aspects of the market, i.e. PIC design for manufacturing & test, but some business and management details that are of paramount importance in a professional, i.e. how much does your chip cost, how this is related to the cost structure of your company, and how to mark it up to the a price that both generates revenue and is on-market, amongst other.

[1] Photonic Integrated Circuit Market - Global Industry Size, Share, Trends, Analysis, and Forecast, 2012 - 2018, <http://www.transparencymarketresearch.com/photonic-integrated-circuit.html>

[2] Silicon Photonics: Big Investments, Small Business, 2012, <http://www.reportlinker.com/p01021140-summary/Silicon-Photonics-Big-Investments-Small-Business.html>

#### 6. Recommended Prior Knowledge

- a degree in Electronic Engineering or Physics is advisable.
- background in electromagnetism, optics and photonics is expected.

#### 7. Results

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## 7. Results

### Fundamental results

G01(GE) The ability to conceptualise, calculate and design products, processes and facilities in all fields of Telecommunications Engineering.

T03(ES) The ability to implement systems via cables, lines and satellites that use both fixed and mobile communication.

G08(GE) The ability to apply acquired knowledge and solve problems in new or unknown settings within wide and multidisciplinary environments while being capable of integrating knowledge.

### UPV-Generic Student Outcomes

#### (1) Social and environmental commitment

- Activities carried out to achieve the student outcome

Developed and evaluated in the course materials, both in lecture room and laboratory activities.

- Assessment criteria

The transversal competences will be evaluated and graded within the written tests.

#### Specific Learning Outcomes

RA1.4 - Design, develop and implement solutions in the field of the discipline that respond to social demands, taking into account the Sustainable Development Goals and global, cultural and economic factors.

#### (2) Innovation and creativity

- Activities carried out to achieve the student outcome

Developed and evaluated in the course materials, both in lecture room and laboratory activities.

- Assessment criteria

The transversal competences will be evaluated and graded within the written tests.

#### Specific Learning Outcomes

RA2.1 - Identifying new challenges, projects or opportunities for improvement in the field of the discipline aligned with future trends and advances.

## 8. Syllabus

### 1. ECOSYSTEM

1. History, evolution, context, technologies
2. Supply chain, market trends

### 2. TECHNOLOGY

1. Waveguides
2. Couplers
3. Interferometers
4. Modulators
5. Filters
6. Circuit design

### 3. PRODUCTION

1. Introduction to manufacturing
2. Manufacturing platforms
3. Packaging & layout
4. Test and measurement

### 4. BUSINESS

1. Fabless model financial aspects
2. Company presentations

## 9. Teaching and Learning Methodologies

Lab sessions:

- Waveguides (3 sessions x 2 hours / session)
- Couplers (3 sessions x 2 hours / session)
- Interferometers and filters (3 sessions x 2 hours / session)
- Layout (3 sessions x 2 hours / session)

<u>UN</u>	<u>LE</u>	<u>SE</u>	<u>PS</u>	<u>LS</u>	<u>FW</u>	<u>CP</u>	<u>AA</u>	<u>CH</u>	<u>NCH</u>	<u>TOTAL HOURS</u>
1	4,00	--	0,00	0,00	--	--	2,00	6,00	6,00	12,00
2	14,00	--	4,00	16,00	--	--	12,00	46,00	49,00	95,00





## 9. Teaching and Learning Methodologies

<u>UN</u>	<u>LE</u>	<u>SE</u>	<u>PS</u>	<u>LS</u>	<u>FW</u>	<u>CP</u>	<u>AA</u>	<u>CH</u>	<u>NCH</u>	<u>TOTAL HOURS</u>
3	10,00	--	2,00	8,00	--	--	8,00	28,00	18,00	46,00
4	2,00	--	0,00	0,00	--	--	1,00	3,00	3,00	6,00
<b>TOTAL HOURS</b>	<b>30,00</b>	<b>--</b>	<b>6,00</b>	<b>24,00</b>	<b>--</b>	<b>--</b>	<b>23,00</b>	<b>83,00</b>	<b>76,00</b>	<b>159,00</b>

UN: Unit. LE: Lecture. SE: Seminar. PS: Practical session. LS: Lab sessions. FW: Field work. CP: Computer-mediated practice. AA: Assessment activities. CH: Contact hours. NCH: Non contact hours.

## 10. Assessment

### Outline

- (15) Practical laboratory/field/computing/classroom test
- (14) Written test

### Num. Acts Weight (%)

4	35
10	65

In the case of distance students, with exemption from the obligation to attend, the evaluation will be carried out by means of a polifomat exam.

It will be possible to recover 70% of the grade through 1 final written test.

The transversal competences will be evaluated and graded within the written tests.

The written tests will comprise a mix of on-line examinations (comprising assignments+quiz, up to 8) and written paper and pen (traditional) examinations (up to 2), to a maximum total of 10 written tests. The traditional examinations will comprise up to 40% of the final mark (leaving a maximum of 25% for the on-line examinations).

A minimum mark in the (combined) traditional examinations of 4 points out of 10 is required to average with the other marks in the course.

## 11. Absence threshold

<u>Activity</u>	<u>Percentage</u>	<u>Observations</u>
Lecture Theory	0	
Seminar Theory	0	
Lecture Practice	0	
Laboratory Practical	0	
Computer Practice	0	
Field Practice	0	

