Master in PHOTONICS BCN
(http://www.photonics.masters.upc.edu)

Master Erasmus+ EUROPHOTONICS-POESII
(http://www.europhotonics.org/)

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PHOTONICS, the science and technology of LIGHT

- Optics & photonics: a traditional area of science & technology evolving very fast.
- One of the most relevant branches of Science & Technology for the 21st century technological development. It has been selected by the European Union as one of the five KET “Key-Enabling Technologies”.
- Highly multidisciplinary.
Main branches of PHOTONICS:

- Classical optics: geometrical, electromagnetic, ...
- Imaging and vision
- Light sources (LED, laser,...), lighting
- Displays
- Sensors and cameras
- Biomedical photonics (therapy and diagnostics)
- Optics and photonics engineering
- Optical communications and remote sensing
- Materials processing: cutting, 3D printing,...
- New materials and devices: nanophotonics, photonic crystals,...
- Energy, environment: solar panels, green photonics,...
- Quantum optics and technology, quantum information, non linear optics, ...

[Imagery: FP displays, Optical components, Graphene technology, Non-linear microscopy, Laser therapy]
Photonics in Science and Technology

PHOTONICS SEGMENTS

- FP Displays: 28%
- IT: 17%
- Medical and Life Science: 12%
- Lighting: 8%
- Measurement and Image Processing: 8%
- Photovoltaics: 8%
- Defence and Security: 7%
- Production Technology: 7%
- Optical Component and Systems: 6%
- Optical Comms: 5%
- Other: 5%

PREDICTED MARKET SIZE IN 2020

<table>
<thead>
<tr>
<th>Segment</th>
<th>Market Size (in Billion Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparel Retail</td>
<td>1.650</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>1.100</td>
</tr>
<tr>
<td>Photonics</td>
<td>724</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>400</td>
</tr>
</tbody>
</table>

PREDICTED CAGR* (%) (2017-2020/22)

<table>
<thead>
<tr>
<th>Segment</th>
<th>CAGR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photonics</td>
<td>8,5</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>8</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>6,3</td>
</tr>
<tr>
<td>Apparel Retail</td>
<td>4,6</td>
</tr>
</tbody>
</table>

*Compound Annual Growth Rate
Optics & Photonics

- **2007**: Nature journals about Photonics are created
  - “Nature Photonics” journal
  - “Light: Science & Applications”, open access.

- **2010**: EU selects Photonics as one of the five KET (“Key-Enabling Technologies”)

- **2013**: USA: National Photonics Initiative – “Optics and Photonics. Essential technologies for our nation” (2012) - A collaborative alliance among industry, academia and government seeking to raise awareness of photonics

- **2015**: China: “Laser World of Photonics” trade fair, held in China for the 1st time.

- **2015**: International Year of Light, and of technologies based on light

**XXI century**: - 8 Nobel Prize in Physics
- 2 Nobel Prize in Chemistry related to PHOTONICS
MSc Photonics – “PHOTONICS BCN”

- 15 years ago, researchers covering different fields of Photonics in Barcelona area (UPC, UAB and UB) and in the Institute of Photonic Science (ICFO), decided to put together their complementary expertise to offer a joint Master in Photonics.

**GOAL:** Provide knowledge and training in different areas of Photonics, considering both fundamental and applied aspects.

- The program started in 2007
- Official 60 ECTS (1 year) Spanish Degree.
- All courses are taught in English.
Masters in Photonics & Master Erasmus+ Europhotonics

60 ECTS (1 year): Spanish degree

120 ECTS (2 years): multiple degree (Spanish, French and German)

European Erasmus+ Mobility Program
<table>
<thead>
<tr>
<th>Academic year</th>
<th>Master in Photonics</th>
<th>Europhotonics</th>
<th>Erasmus Mobility</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-08</td>
<td>21</td>
<td></td>
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<tr>
<td>2008-09</td>
<td>32</td>
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<tr>
<td>2009-10</td>
<td>25</td>
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</tr>
<tr>
<td>2010-11</td>
<td>26</td>
<td></td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>2011-12</td>
<td>26</td>
<td>18</td>
<td>2</td>
<td>46</td>
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<tr>
<td>2012-13</td>
<td>26</td>
<td>5</td>
<td>6</td>
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<td>2013-14</td>
<td>27</td>
<td>5</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>2014-15</td>
<td>23</td>
<td>7</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>2015-16</td>
<td>29</td>
<td>4</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>2016-17</td>
<td>28</td>
<td>5</td>
<td>14</td>
<td>46</td>
</tr>
<tr>
<td>2017-18</td>
<td>26</td>
<td>6</td>
<td>14</td>
<td>46</td>
</tr>
<tr>
<td>2018-19</td>
<td>26</td>
<td>2</td>
<td>9</td>
<td>37</td>
</tr>
</tbody>
</table>

**BSc degree:**
- 18 Physics
- 1 Engineering physics
- 1 Physics Chemistry
- 2 Optics & Optometry
- 5 Engineers: telecommunications, electric & electronics,
## Compulsory courses

<table>
<thead>
<tr>
<th>Course</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Photonics</td>
<td>10 ECTS</td>
</tr>
<tr>
<td>• Introduction to photonics. Optics and Lasers</td>
<td>5 ECTS</td>
</tr>
<tr>
<td>• Beam Propagation and Fourier Optics</td>
<td>5 ECTS</td>
</tr>
<tr>
<td>Applied Photonics &amp; Transversal Skills</td>
<td>10 ECTS</td>
</tr>
<tr>
<td>• Photonics Laboratory</td>
<td>5 ECTS</td>
</tr>
<tr>
<td>• Business and Patents in Photonics</td>
<td>5 ECTS</td>
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</tbody>
</table>

## Elective Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantum Optics (QUANTOP)</td>
<td>18 ECTS</td>
</tr>
<tr>
<td>Biophotonics and Imaging (BIOIMA)</td>
<td>12 ECTS</td>
</tr>
<tr>
<td>Materials and Nanophotonics (MATNANO)</td>
<td>12 ECTS</td>
</tr>
<tr>
<td>Telecomm. &amp; Photonics Circuits (TELPHO)</td>
<td>12 ECTS</td>
</tr>
<tr>
<td>Optical Engineering (OPTENG)</td>
<td>12 ECTS</td>
</tr>
<tr>
<td>Master Thesis</td>
<td>16 ECTS</td>
</tr>
</tbody>
</table>

**Total: 60 ECTS**
### Module 2: Elective courses  
*(free choice of 24 ECTS)*

<table>
<thead>
<tr>
<th>Teaching Unit 2.1: Quantum Optics</th>
<th>15 ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Quantum Optics</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Quantum simulators, Bose Einstein condensates and ultracold quantum gases</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Quantum Information theory: communic. &amp; comput.</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Advanced Quantum Optics with Applications</td>
<td>3 ECTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Unit 2.2: Biophotonics and Imaging</th>
<th>12 ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Optical image in biology and medicine</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Optical micromanipulation workshop</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Visual optics and biophotonics</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Image processing in biophotonics</td>
<td>3 ECTS</td>
</tr>
</tbody>
</table>
Module 2: **Elective courses** (free choice of 24 ECTS)

<table>
<thead>
<tr>
<th>Teaching Unit 2.3: Materials and Nanophotonics</th>
<th>12 ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Photonics materials and metamaterials</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Nonlinear Optics</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Nanophotonics</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Ultrafast and ultraintense laser light</td>
<td>3 ECTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Unit 2.4: Telecommunications and Photonic Circuits</th>
<th>12 ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fibers and telecommunications</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Integrated Photonics</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Photonics systems in telecommunications</td>
<td>3 ECTS</td>
</tr>
<tr>
<td>• Optoelectronics and photovoltaic technology</td>
<td>3 ECTS</td>
</tr>
</tbody>
</table>
### Module 2: Elective courses

**Teaching Unit 2.5: Optical Engineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser systems and applications</td>
<td>3</td>
</tr>
<tr>
<td>Building optomechanical systems</td>
<td>3</td>
</tr>
<tr>
<td>Managing light with devices</td>
<td>3</td>
</tr>
<tr>
<td>Measuring with light</td>
<td>3</td>
</tr>
<tr>
<td>Active and spectral imaging</td>
<td>3</td>
</tr>
</tbody>
</table>

*free choice of 24 ECTS*
SPECIAL FEATURES

- **“TRANSVERSAL or COMPLEMENTARY skills”**
  - *Business and Patents in Photonics* allows contacts with professionals with high responsibility in companies, and fosters entrepreneurial and communication skills.
  - *“Seminar and Skills”* - sessions of oral & written expression in English.

- **Activity weeks:** visits to labs. or companies, presentations, simulations, experiments,...

- Seminars and visiting professors

- Wide election of the Master Thesis (more than 50 proposals/year)

- PhD grants and Job advertisements (webpage section)

- **Members of SECPhO:** contact with companies
PROFESSORS: more than 60

Universitat Politècnica de Catalunya (23 professors)
  Department of Optics & Optometry
  Department of Physics
  Department of Signal Theory and Communications
  Department of Electronics Engineering

Universitat Autònoma de Barcelona (10 professors)
  Department of Physics, Optics Group
  Department of Physics, Quantum Information Group

Universitat de Barcelona (12 professors)
  Department of Applied Physics and Optics
  Department of Electronics
  Department of Matter Structure & Constituents

Institut de Ciencies Fotòniques (ICFO) (17 group leaders)
- Optical engineering: sensors, vision, metrology, opt. design, adaptive optics, color science
- Image processing, liquid crystal, machine vision
- Nonlinear optics and dynamics
- Nanomaterials, remote sensing
- Optical Fiber Communications & networks
- Integrated photonics

- Applied optics: image proc., diffractive optics
- Thin films
- Optical tweezers
- Optoelectronics devices, CMOS
- Quantum information

- Quantum & Nonlinear Optics, Quantum information
- Image processing, diffractive optics, metrology.
- Synchrotron light, X-ray optics
- Thin films, multilayers.

- Nanophotonics
- Advanced optical imaging
- Quantum & atom optics
- Nonlinear optics & devices, ultrafast light
- Biophotonics, optical tweezers
- Photonic materials
Module 3: Master Thesis

More than 50 Master thesis proposals from UPC, UAB, UB, ICFO and companies

- Institute of Photonic Sciences, ICFO - http://www.icfo.es
- Centre for Sensors, Instruments and Systems Development, CD6 (UPC) - http://www.cd6.upc.edu
- Applied Optics and Image Processing Research Group, GOAPI (UPC) - http://www.goapi.upc.edu
- Remote Sensing Research Group, RSLAB (UPC) - http://www.tsc.upc.edu/rs/
- Free-space Optical Communications (UPC) - http://www.tsc.upc.edu/fsoc/
- Optical Communications Group, GCO (UPC) - http://www.tsc.upc.es/gco
- Group on Nonlinear Dynamics, Nonlinear Optics and Lasers, DONLL (UPC) - http://donll.upc.edu
- Micro and Nano-technologies Research Group, MNT (UPC) - http://webmnt.upc.es
- Optics Group (UAB) - http://optica.uab.es
- Quantum Information Group (UAB) - http://grupsderecerca.uab.cat/giq
- Quantum and Atom Optics Group (UAB) - http://grupsderecerca.uab.cat/qaos
- Optical Trapping Lab (UB) - http://www.ub.edu/biopt
- Diagnosis of skin cancer with spectral imaging:

- Spectral fundus imaging:
- Clinical, objective evaluation of the visual function based on the analysis of ocular movements (eyetracking):

- Improving OCT imaging:
Careers in Photonics

Very broad, given the interdisciplinary character and increasing relevance of photonics:

- PhD in Photonics and joining education and high-level training in the field of photonics.
- R&D and innovation programs in companies, basic or applied research centers or universities.
- Consultant / engineer on photonics-related issues.
- High-level qualification technical positions for laboratory / technological / medical services as microscopy, medical industry (ophthalmology and optometry), x-ray diffraction, thin films, etc.
- Joining (and promoting) spin-off or other technology-based small companies.

Which was your first position/job after the Master graduation?

- PhD/Researcher 73%
- Company 21%
- Others 6%

How long did it take for you to find a position after the graduation?

- Less than 3 months 22
- Less than 6 months 4
- Less than 1 year 6
- > 1 year 1
Master in Photonics ranked with the maximum evaluation “EXCELLENCE” in the last evaluation.
**Master in Photonics**

**Master Council:**
- Crina Cojocaru (UPC)
- Ramon Alcubilla (UPC)
- Adolf Comerón (UPC)
- Josep Pladellorens (UPC)
- Salvador Bosch (UB)
- Ignasi Juvells (UB)
- Juan Campos (UAB)
- Ramón Corbalán (UAB)
- David Artigas (ICFO)
- 2 students: to be assigned

**Executive committee:**
- Crina Cojocaru (director)
- Ramon Vilaseca (co-director)
- Meritxell Vilaseca (UPC coordinator)
- Jordi Mompart (UAB coordinator)
- Artur Carnicer (UB coordinator)
- David Artigas (ICFO coordinator)

**Academic Management:**
- ETSETB –UPC
  - **Director:** Ferran Marques
  - **Master coordinator:** Jordi Casademont
  - **International coordinator:** Jose António Lázaro
  - **Head of admin. staff:** Àngels Hurtado
MSc Photonics & Europhotononics