EU IST-511616

PHOREMOST

"Nanophotonics to Realise Molecular-Scale Technologies"

Instrument: EU Network of Excellence
Thematic Priority: **IST**

P*hOREMOST* Training Courses Handbook

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PU	Public	X
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group specified by the consortium (including the Commission	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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P*h*OREMOST Training Courses Handbook

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With contributions from
P*h*OREMOST Partners

Date of preparation:
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Disclaimer

While every effort has been made concerning the accuracy of the information presented, we apologise for any errors incurred when preparing a document containing information coming from several sources of higher education in Europe.

Contents

Introduction

We proudly present in this handbook details of courses on Nanophotonics available at the institutions of the partners involved in the European network of excellence "PhOREMOST" (*Nanophotonics to realise molecular scale technology*). The handbook aims to inform students and researchers of the education and training opportunities available in the field, and related fields, of nanophotonics.

The PhOREMOST network of excellence is a consortium of 34 partners from across Europe, from universities, research centres and industry, all working in the area of nanophotonics and molecular photonics. It is the goal of the network to join together, and strengthen, the current research efforts in these fields. In doing this, the network hopes to develop the underpinning science and engineering needed to put molecular-based optical components in the market. Therefore, an essential step in achieving these aims is to educate and train students and researchers for European academia and industry.

In this handbook you will find details of relevant courses/training opportunities, both academic and industrial, grouped under the following headings:

- Nanomaterials and Nanostructures;
- Photonics;
- Optics and Quantum optics;
- Applied Photonics and Nanophotonics;
- Biophotonics;
- Semiconductor materials, and
- Imaging.

The level of the courses would suit the Master's and Ph.D. curricula. However within the course details, you will also find lists of recommended books and journal publications that may be useful for all researchers.

From the practical point of view, those who want to undertake a course in a partner's organisation should in the first hand contact the responsible lecturer of the course to get all the details regarding eligibility criteria (both academic and financial) for admittance.

We would like to thank all the members for providing us with the data compiled here. While every effort has been made concerning the accuracy of the information presented here, we will be glad to rectify any error incurred when preparing a document constituting contributions from the whole Europe, in the future editions. Please send all the suggestions to the main editor, Prof. Sebastian Lourdudoss (e-mail: doss@imit.kth.se).

Sebastian Lourdudoss
Audrey McSweeney

Description of Courses

Nanomaterials and Nanostructures

(Includes Physics and Technology)

Introduction to Nanoscience

Partner name, place and country	**Technical University of Dresden, Dresden, GERMANY**
Partner number	**16**

General information

Institute:	Physical Chemistry, TU Dresden
Target group	Senior undergraduates/Graduates
Course code	
Language of Instruction	English and German
ECTS Credits:	
Period	October-January and April-July
Course website	
Lecturer/contact person	Prof. A. Eychmüller/ Dr. N. Gaponik
e-mail address	nikolai.gaponik@chemie.tu-dresden.de

Description of the Course

Aims:
Description of nanoscience basics: Gain knowledge on the unique properties of nanomaterials, on the state of the art in and the perspectives of the nanotechnology

Objectives:
Basic theoretical background as well as knowledge of various methods of synthesis and/or fabrication of nanoparticles and nanostructures, their characterisation and applications

Course Structure:

1. Lectures
Introduction to Nano, Overview of nanofabrication methods, Synthesis of colloidal nanocrystals, Assembly of nanoparticles, Spectroscopy of the nanoobjects, Microscopy of the nanoobjects, How to address nanoobjects, Nanodevices and promising applications of nano

2. Laboratory (practical work)
Colloidal Synthesis of Nanocrystals

3. Material available

Type	Languages/format
Description of practicum	German

4. Prerequisites:
Basic course of Physical Chemistry

Study Times

Type	Hours
Lectures	28/Semester
Laboratory Work	6
Self study and report writing*	28*2 and 6*2

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Proper lab report	Lab report written by a group of 2 students

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Schmid (Ed.)	Nanoparticles	WILEY-VCH	2004	3-527-30507-6	159.- €	C
Wang (Ed.)	Characterization of Nanophase Materials	WILEY-VCH	2000		159.- €	C
Ozin, Armentrout	Nanochemistry	RSC Publishing	2005	0-85404-664-X	39.95 GBP	C

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Nanoscience

Partner name, place and country	**Weizmann Institute of Science, Rehovot Israel.**
Partner number	**20**

General information

Institute:	Weizmann Institute of Science
Target group	Grad. students
Course code	20062102
Language of Instruction	English
ECTS Credits:	2
Period	2 semesters
Course website	http://infstud-dmz.weizmann.ac.il/pls/app/fein_courses.details?f_course_code=20062102
Lecturer/contact person	G.Hodes/S. Cohen
e-mail address	Gary.hodes@weizmann.ac.il

Description of the Course

Aims:
Provide a general overview of nanoscience-related topics.

Objectives:
Basic knowledge of nanoscience.

Course Structure:

The course will introduce some of the fundamental principles of nanoscience: Structures and phenomena at a size scales well below a micron, which express unique, size-related characteristics.
Topics to be covered (over 2 semesters):
Synthesis, (electro) chemical prep including nucleation and growth, evaporation, sputtering , MBE, ALE, ALD,CVD, nanotube preparation, Fabrication
Self-Assembly. What is it? Why is it a key element of nanofabrication?
lithography - optical based; electron beam-based; x-ray based; physical and chemical alternatives (including scanning probe-based), MEMS and NEMS, Data Storage,
Properties- Physical effects of increased surface/volume ration for small particles; forces governing interactions between small particles; special considerations in measuring small objects and small ensembles. Kinetic and thermodynamic considerations of surface processes. Quantum size effects on electronic levels and electron transport, Nanomechanics - How and why should mechanical properties vary at small sizes. How can these properties be predicted and evaluated? Effects of

adhesion, stiffness, dominance of different mechanical interactions at different size scales. Electronic phenomena- Quantum size effects on electronic levels and electron transport, Single electron effects, Molecular Electronics, Solar Cells, Optical effects: Optical interactions on the nanometer scale, Quantum dots and quantum confinement, near field optics for sub micron resolution, photonic structures (waveguides, filters,), plasmonic devices. Measurement - Spectroscopy, electron microscopy, X-ray diffraction, scanning probe techniques. Calculations: Modelling and theory of quantum size effects, Special properties of Nanoparticles, Nanoparticles in the atmosphere, Nanotubes.

1. Laboratory (practical work) none

2. Material available

Type	Languages/format
Handouts/email	English

3. Prerequisites: Math 1 (Chem or Math sciences); Physical Chemistry; Basic Materials 1

Study Times

Type	Hours
Lectures	54 hrs
Homework/seminar prep.	40 hrs
Self study and report writing*	

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
	Homework, student seminars, exam.	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Physics of Nano Structures

Partner name, place and country	**LENS, Univ. of Florence, Italy**
Partner number	**2**

General information

Institute:	Dept. of physics, Univ. of Florence, Sesto Fiorentino (Florence), Italy
Target group	Senior undergraduates/Junior graduates
Course code	FIS/03
Language of Instruction	Italian
ECTS Credits:	3
Period	September – December (every year)
Course website	http://www3.unifi.it/clfisi/upload/sub/laurea_specialistica/manifesto_LS_2006-7.pdf
Lecturer/contact person	Prof. Massimo Gurioli
e-mail address	gurioli@lens.unifi.it

Description of the Course

Aims:

To gain knowledge in the unique physics of nano structures, in particular with regard to their optical properties.

This course is given as a specialization course after the standard under-graduation degree and can be followed by PhD students as well.

Objectives:

Understand the physics behind the optical properties of nano structured materials, with a focus on solid state structures, as quantum dots, wells, and cavities. Understand how the band structure leads to particular optical effects. Learn about applications of these materials.

Course Structure:

1. Lectures

General introduction, heterostructures and engineering of the bandgap. Nano structures and quantum confinement. Quantum wells, quantum wires and dots. Lasers based on double hetero structures, quantum wells, and dots. Coulomb blockade and single electron transistors. Devices based on tunneling, HFET, and ballistic devices. Quantum cascade lasers.

2. Laboratory (practical work)

none

3. Material available

Type	Languages/format
Handouts	Italian

4. Prerequisites:
Basic courses on solid state physics and quantum mechanics.

Study Times

Type	Hours
Lectures	30 hours
Laboratory work	0
Self-study and report writing*	30 hours

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Examination	Written / oral

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
To be defined at course						B

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Photonics and Nanophotonics

Introduction to Photonics

Partner name, place and country	**UPC, Universitat Politècnica de Catalunya, Barcelona, Spain**
Partner number	**23**

General information

Institute:	UPC, Universitat Politècnica de Catalunya, Barcelona, Spain
Target group	Junior graduates
Course code	
Language of Instruction	English
ECTS Credits:	5
Period	Fall semester
Course website	http://www.fen.upc.edu/wfen/doctorat/cjtodoctorat.htm
Lecturer/contact person	Prof. Jordi García-Ojalvo and Prof. Jordi Martorell
e-mail address	jordi.martorell@icfo.es

Description of the Course

Aims:

To provide the student an overview of the basic concepts behind photonics

Objectives:

Introduction to basic concepts in photonics, such as light propagation in several types of media, diffusive, structured, guided waves, etc., and of radiation matter interaction including the study of the basic processes of light emission, laser light generation, nonlinear interaction, ...

Course Structure:

1. Lectures

- Light Propagation: Homogeneous media, EM waves at interfaces, Diffusive media, Scattering by small particles, periodically structured materials, Wave guiding, Optical Fibers.
- Light-Matter Interaction: Two-level systems, EM field quantization, Stimulated emission, Spontaneous emission, Raman scattering.
- Light Sources: Incoherent light sources, Laser amplification, Types of amplifying media and pumping schemes, Amplifier nonlinearity and gain saturation, Theory of laser oscillation, Characteristics of the laser output.
- Dynamics of light-matter interaction: Laser oscillation build-up, Pulsed lasers, Maxwell-Bloch and rate equations, Bistable optical devices, Self-pulsing devices, Chaos in optical systems.
- Light detection and conversion to electricity: Thermal detectors, Photomultiplier

tubes, Photodiodes, Solar cells.

- Non-Linear Interaction: Second-order nonlinear interaction, Materials for nonlinear optics, Second harmonic generation, Parametric Processes, Spontaneous parametric down-conversion, Parametric Oscillation, Third order nonlinearities, Kerr effect.

2. Laboratory (practical work)

None

3. Material available

Type	Languages/format
-	-

4. Prerequisites:

Basic courses on Electromagnetic waves, Solid State Physics and Quantum Mechanics.

Study Times

Type	Hours
Lectures and tutorials/seminars	30 hours
Self-study and report writing*	30x2,5 hours

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Written reports	

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
B. E. A. Saleh and M. C. Teich	Fundamentals of Photonics	John Wiley & Sons	1991	ISBN 0-471-83965-5	ca 140 €	B

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Introduction to Lasers and Photonics

Partner name, place and country	**Tyndall National Institute, Cork, Ireland**
Partner number	**1**

General information

Institute:	University College of Cork, Ireland
Target group	
Course code	PY4052
Language of Instruction	English
ECTS Credits:	-
Period	Period 2
Course website	http://www.ucc.ie/academic/modules/descriptions/page057.html#PY4052
Lecturer/contact person	Professor Michael Mansfield, Department of Physics
e-mail address	M.Mansfield@ucc.ie

Description of the Course

Aims:
To introduce the physics of modern photonic devices and photonic communications.

Course Structure:

1. Module Content:
Basic optics including diffraction, Gaussian modes and Fabry-Perot Etalons. Optical waveguides. Physical origins of optical gain in various media. Lasers, stimulated and spontaneous emission, lasing modes and linewidth. Introduction to optical communications, bandwidth, noise and dispersion. Second Harmonic Generation. Detectors and modulators based on bulk and quantum well absorption regions. Modern waveguide devices: splitters and combiners, including MMI (multimode interference) combiners, AWGs (arrayed waveguides) and Echelle gratings. Modern trends in Photonics such as Integrated Photonics, Optical Data Storage, and DWDM (dense wavelength division multiplexing).

2. Teaching Methods:
36 x lectures; 15 x Tutorials; 3 x Seminars; Laboratory

3. Material available

Type	Languages/format

4. Prerequisites:
Electromagnetic theory to the level of PY3053, AM3022 or equivalent

Study Times

Type	Hours
Lectures	36
Tutorials	15
Seminars	3

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
70	Written Examination	End of Year 1 x 3hr(s) Papers (140 marks)
30	Continuous Assessment	In-term Laboratory Work and Homework Assignments 30 marks; quizzes, MCQ's, End of Year Departmental Tests and/or Laboratory Examinations 30 marks (60 marks)

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Nanophotonics

Partner name, place and country	**Vilnius Pedagogical University, Vilnius, Lithuania**
Partner number	**13**

General information

Institute:	Vilnius Pedagogical University, Vilnius, Lithuania
Target group	Masters
Course code	TFSKF – 315
Language of Instruction	English
ECTS Credits:	4.5
Period	September – December (every year)
Course website	http://www.ftf.vpu
Lecturer/contact person	Prof. Rimas Vaisnoras
e-mail address	vaisnoras@vpu.lt

Description of the Course

Aims:

The main aim of this course is to introduce students with artificial materials – photonic crystals, applications and light propagation in the PBG materials.

Photonic band gap (PBG) materials are a novel class of photonic crystals that carry the concept of molding the flow of light to the most microscopic level allowed by the laws ol physics. Consisting of dielectric microstructures with periodicity of roughly half the wavelength of light, PBG materials scatter photons in a manner similar to the scattering of electrons by the crystalline array of atoms in a semiconductor. The resulting gap in the electromagnetic spectrum provides a unique environment in which unwanted pathways for electromagnetic wave propagation are removed and desired ones can be selectively engineered, through defects in the photonic crystal lattice. In this way, a PBG material provides a robust platform for the integration of passive optical circuitry and active light emitting devices onto a compact optical micro-chip. Moreover, the electromagnetic density of states on the optical micro-chip can be engineered through suitable crystal defect architectures. This enables highly frequency selective changes in the rate of spontaneous emission of light from atoms whose resonance frequency lies within the engineered electromagnetic vacuum. This provides a new frontier in the field of quantum optics. The possibilities outlined above have inspired a worldwide effort to design, fabricate, and characterize a variety of different types of photonic crystals.

Course Structure:

1. Lectures

Photonic band structure computation. Density of states. Group velocity and group velocity dispersion. Nonlinear photonic crystals. Finite structures. Defected structures in photonic crystals. Maximally localized photonic functions. Wannier description of defect structures. Localized cavity modes. Dispersion relations of waveguides. Light propagation through photonic crystal circuits. Materials. Porous silicon. Porous alumina. Porous III-V semiconductors. Application to photonic crystals. 2D photonic crystals made of macro porous silicon. Photonic defects in electrochemically-prepared 2D photonic crystals. 3D photonic crystals made of macroporous silicon. 2D photonic crystals made of porous alumina. Preparation of monodisperse colloids. General methods. Preparation of functional core shell structures. Crystallization into opaline structures. Sedimentation. Crystallization mediated by the magnetic field. Two dimensional crystallization to photonic crystal films. Structured photonic crystals. Lateral patterning. Preparation of heterostructures from different colloids. Replica from opaline structure. Introduction: Concepts of tunable photonic crystals. Properties of liquid crystals. Spatially periodic LCs and colloidal crystals. Periodic liquid crystals. Colloidal crystals containing LCs. Polymer-dispersed liquid crystals. Microstructured semiconductors. Macroporous silicon. Group III-V semiconductors.
Possible applications of macroporous silicon. Possible applications for tunable planar III/V-semiconductor photonic crystals.

2. Laboratory (practical work)

4. Material available

Type	Languages/format

4. Prerequisites:
Basic courses on solid state physics, materials science and quantum mechanics.

Study Times

Type	Hours
Lectures and tutorials/seminars	48
Self study and report writing*	

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Written examination	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Kazuaki Sakoda	Optical Properties of Photonic Crystals	Springer	2004	3540206825	$77	C
K. Busch, S. Lolkes, R. B. Wehrspohn, and H. Foll	Photonic Crystals	Wiley	2004	3-527-40432-5	106 €	C

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Photonics from Micro to Nano-scale

Partner name, place and country	**ICFO-Institut de Ciències Fotòniques, Barcelona, SPAIN**
Partner number	**3**

General information

Institute:	ICFO-Institut de Ciències Fotòniques
Target group	PhD Students
Course code	
Language of Instruction	English
ECTS Credits:	30 hours
Period	May
Course website	http://www.icfo.es/index.php?section=teaching2&lang=english
Lecturer/contact person	Prof. Gonçal Badenes
e-mail address	Goncal.badenes@icfo.es

Description of the Course

Aims / Objectives:
The objective of this course is to provide students with a precise vision on some of the current topics of research in Nanophotonics. Special attention is paid to the basics, fabrication and characterization techniques related to sensing and light-emission applications.

Course Structure:

1. Lectures

Fundamentals
Organic/hybrid light emitting materials
Resonators
Nanoparticles
Surface plasmons / localised surface plasmons
Gratings

Fabrication techniques
Self-assembling
Micro- and nano-fabrication
Deposition techniques
Lithography: optical and electron-beam
Etching

Characterisation techniques
Near-field optics and near-field microscopy
Spectroscopy

Applications
Organic & hybrid light sources
Sensors
Light manipulation

2. Laboratory (practical work)

3. Material available

Type	Languages/format

4. Prerequisites:

Study Times

Type	Hours
Self study and report writing*	

These times are rough estimates of the work by a typical student.

Assessment

%	Type	Details
	Research work/report	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
S. Kawata, M. Ohtsu, M. Irie,	*Nano-Optics*	Springer-Verlag	2002			
R. W. Boyd	Nonlinear Optics	Academic Press	2003			
P. N. Prasad	Introduction to Biophotonics	Wiley-Interscience, John Wiley and Sons	2003			
A. Moliton	Optoelectronique moleculaire et polymere: des concepts aux composants	Springer	2003			

A.J. Heeger	Nobel Lecture: Semiconducting and metallic polymers: The fourth generation of polymeric materials	Review of Modern Physics, vol. 73, 681	2001
R. H Friend et al.	Electroluminescence in conjugated polymers	Nature vol. 397, 121	1999

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Molecular Nanophotonics

Partner name, place and country	**ENS Cachan, Cachan, Franc**
Partner number	**29**

General information

Institute:	ENS Cachan
Target group	Senior undergraduates
Course code	MONABIPHOT/ **Molecular Nanophotonics**
Language of Instruction	English
ECTS Credits:	5
Period	September-December (every year)
Course website	www.ens-cachan.fr/monabiphot
Lecturer/contact person	Isabelle Ledoux / Emmanuelle Deleporte
e-mail address	ledoux@lpqm.ens-cachan.fr deleporte@lpqm.ens-cachan.fr

Description of the Course

Aims:
This course, which is devoted to Nanophotonics, covers both theoretical and practical aspects of the physical description, the fabrication and the characterisation techniques of nano-objects and nanostructures for photonics

Objectives:
To understand the specific optical properties of nano-object as compared to the corresponding bulk materials ; to know about elaboration techniques of quantum dots. To understand the basic principles of confocal microscopy applied to nonlinear and/or luminescent nanostructures.

Course Structure:
I. Nanostructures for photonics: description and fabrication methods (12h)
1. Molecular nano-objects: fullerenes, nanotubes, dendrimers, cyclodextrines…
2. Nanoparticles: preparation and functionalization
3. Nanocavities and nanoporous materials: zeolites, nanostructured sol-gels, ion channels
4. Bulk insertion and macroscopic organization

II. Physics at the nanometric scale and applications to photonics (24h)
1. Definitions and Basics: state densities, 3D electron gases, bandgap structures, excitons, polaritons, strong coupling
2. 2D, 1D and 0D quantum confinement. Electron and photon behaviour. Illustrations in carbon nanotubes.
3. Interaction between nano-objects and light.

III. Instrumentation in nanophotonics and applications (16h)
1. Structural microscopy techniques: electron microscopy (EM), atomic force microscopy (AFM), tunneling microscopy

2. Optical microscopy: luminescence, nonlinear effects (two-photon fluorescence, second and third harmonic generation, surface enhanced Raman scattering)
3. Nano-objects manipulation: AFM, optical tweezers
4. Application to Biology (in connection with the biophotonics I and II courses)

1. Laboratory (practical work)

2. Material available

Type	Languages/format
Handouts	English

3. Prerequisites:
Basic knowledge in solid-state physics and in optics

Study Times

Type	Hours
Courses	52
Self study and report writing*	60

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Written examination	4 hours written examination

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Paras Prasad	Nanophotonics	Wiley-Interscience	2004	0471670243	89.95 USD	C

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Modelling and Simulation in Photonics

Partner name, place and country	**UM2, Montpellier, France**
Partner number	**21**

General information

Institute:	University of Montpellier II Place Bataillon 34095 Montpellier Cedex 5, France
Target group	Graduate
Course code	UMPCI302
Language of Instruction	French
ECTS Credits:	5
Period	September-december
Course website	http://www.physique.univ-montp2.fr/article108.html
Lecturer/contact person	Prof. D. Cassagne
e-mail address	cassagne@ges.univ-montp2.fr

Description of the Course

Aims:
This course is devoted to electromagnetism and photonics. The course is part of the master "computational physics". It aims at providing a solid knowledge in the modelisation and simulation of various domains of physics.

Objectives:
To master the main numerical methods for solving Maxwell equations.
To be able to modelize the diffraction by basic structures.
To gain some insight into the new devices of integrated optics.

Course Structure:

1. Lectures
Electromagnetism basics:
Maxwell equations, wave propagation, diffraction, radiation
Numerical method in electromagnetism
Temporal and frequencial methods
Finite Differences and Finite Elements,
Finite Differences Time Domain (FDTD)
Applications in guided optics
Waveguides, optical fibers
Applications in photonics and nanophotonics
Photonic waveguides and cavities
Photonic crystals
Active devices
Application in hyperfrequencies : antenna radiation

Applications to multiphysics

2. Laboratory (practical work)
Use of computational codes: FDTD Finite Difference Time Domain, Finite Elements, Matlab, Comsol MutiPhysics, etc.

3. Material available

Type	Languages/format
Tablet PC presentations	French/pdf

4. Prerequisites:
Maxwell equations, linear algebra, basic programming.

Study Times

Type	Hours
Lectures	30 hours
Laboratory work	20 hours

Assessment

%	Type	Details
100%	Examination	Performed in Computer Lab

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Allen Taflove, Susan C. Hagness	Computational Electrodynamics: The Finite-Difference Time-Domain Method, Third Edition	Artech House	2005	1-58053-832-0	152.13 €	C

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Optics and Quantum Optics

Introduction to Research in Optics

Partner name, place and country	**CSIC, Spain**
Partner number	**5**

General information

Institute:	Instituto de Optica
Target group	Graduates, Postdocs
Course code	
Language of Instruction	Spanish
ECTS Credits:	
Period	April, annual
Course website	http://www.csic.es/postgrado/cursos/Cursos_2006.html#area5_espec_7
Lecturer/contact person	MIGUEL JIMÉNEZ DE CASTRO 9115616800 (ext 2205) Fax: 915645557
e-mail address	iodjc80@io.cfmac.csic.es

Description of the Course

Objectives:
(*What the student would achieve after the course)*
This course aims at providing an introduction to modern optics including vision, image processing, laser matter interaction, new materials, integrated optics, nonlinear optics etc. This will give the students a global perspective through contact with groups directly involved in research in these areas.

Course Structure:

1. Lectures
Theoretical-practical modules
- Physics of vision
- Image processing
- Laser-matter interaction
- Ion-matter interaction
- New materials/systems in integrated optics
- Non linear optics
- Optical processing

2. Laboratory (practical work)

3. Material available

Type	Languages/format
Handouts	Spanish

4. Prerequisites:

Study Times

Type	Hours
Lectures	16

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Modern Optics

Partner name, place and country	**Dep. Physics, University of Dortmund** **Otto-Hahn-Str. 4** **D-44227 Dortmund**
Partner number	**UniDo, partner 28**

General information

Institute:	Dep. Physics, University Dortmund
Target group	Students of Physics, 5. semester and higher
Course code	020215
Language of Instruction	German or English
ECTS Credits:	3
Period	Summer term 2006 (each summer term)
Course website	http://www.physik.uni-dortmund.de/KVV/SS06/SS06_020215.html
Lecturer/contact person	Ulrike Woggon
e-mail address	Ulrike.woggon@uni-dortmund.de

Description of the Course

Aims:
Introduction into fundamentals of wave and geometrical optics, fundamentals of quantum optics, modern optical devices and applications

Objectives:

- Electromagnetic waves, eikonal and rays, Gaussion optics, examples
- Optics at interfaces, reflexion and refraction, guided waves, coupled waves
- Designermaterials with artificial dielectric functions, periodic dielectric functions, photonic crystals, metamaterials
- Optical resonators, cavity modes in 1D und 3D-resonators, mode volume and quality factors, 1-Atom-Laser und threshold-less lasing
- Light sources, thermal light, black-body radiation, non-classical light
- Coherence first and second order, Hanbury-Brown-Twiss experiment, single-photon sources
- Quantum optics of two-level systems, Jaynes-Cumings-Model, Optical Bloch-equations, strong atom-photon-coupling, Rabi oscillations

Course Structure:

1. Lectures

2+1 hours lecture per week

2. Laboratory (practical work)
none

3. Material available

Type	Languages/format
transparencies	English/german, *.pdf and *.ppt

4. Prerequisites:

Physics course 1 to 4, Introduction in Solid State Physics, Higher Quantum Mechanics

Study Times

Type	Hours
Lectures	3
Self study and report writing*	3

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Oral examination	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
R. Gunther	Modern Optics	John Wiley & Sons				B
M. Young	Optik, Laser, Wellenleiter	Springer				C
Born, Wolf	Principles of Optics	John Wiley & Sons				B
Bergmann-Schäfer	Experimentalphysik III	Teubner				B
J. D. Joannopoulos, R. D. Meade, J. N. Winn	Photonic Crystals	Princeton University Press				D

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Experimental Quantum Optics and Quantum Information

Partner name, place and country	**ICFO-Institut de Ciències Fotòniques, Barcelona, SPAIN**
Partner number	**3**

General information

Institute:	ICFO-Institut de Ciències Fotòniques
Target group	PhD Students
Course code	
Language of Instruction	English
ECTS Credits:	40 hours
Period	March-May
Course website	http://www.icfo.es/index.php?section=teaching2&lang=english
Lecturer/contact person	Prof. Juergen Eschner
e-mail address	juergen.eschner@icfo.es

Description of the Course

Aims:
To introduce students to the concepts of experimental quantum information with single atoms and photons, and to review recent experimental progress.

Course Structure:

1. Lectures
1. General concepts of experimental quantum information
2. Trapping & cooling of atoms and ions
3. Generation and control of photons
4. Qu-bits and real atoms; atom-photon interaction
5. Photonic quantum information processing
6. Seminal publications and recent experimental progress

2. Laboratory (practical work)
None

3. Material available

Type	Languages/format

4. Prerequisites:
None

Study Times

Type	Hours
Self study and report writing*	

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
	Active participation	
	Oral contributions	
	Oral/written examination	
	Optional assignments	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
D. Bouwmeester, A. Ekert, A. Zeilinger;	'The physics of quantum information',	Springer	2001			
M.A. Nielsen, I.L. Chuang;	'Quantum computation and quantum information',	Cambridge University Press	2000			

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Optics of Condensed Matter and Nanostructures

Partner name, place and country	**Institute of Molecular and Atomic Physics, Minsk, Belarus**
Partner number	**18**

General information

Institute:	Belarussian State University
Target group	Senior undergraduate
Course code	Not applicable
Language of Instruction	Russian
ECTS Credits:	Not applicable
Period	March-May every year
Course website	Under construction
Lecturer/contact person	Sergey V. Gaponenko
e-mail address	gaponen@imaph.bas-net.by

Description of the Course

Aims:
This course is designed for optical specialty of Physics department. To provide a primary insight to absorption and emission of light by bulk condensed matter and nanoparticles in the context of difference in atomic and molecular optics

Objectives:
Propagation of waves in periodic structures, band formation in solid crystals and photonic crystals, optical transitions in dielectrics and semiconductors, reflection spectra of metals, scattering in complex media, powder colour, primary quantum confinement effects and their optical manifestations, local electromagnetic field effects on emission and scattering of light in metal-dielectric nanostructures

Course Structure:

1. Lectures
Basic properties of simple quantum systems – from a single quantum well to complex multi-well potentials.
Quantum particle in a periodic potential. Band structure of common semiconductor materials.
Analogies of electrons and electromagnetic waves: transmission, reflection, band formation. Photonic crystal concept.
Metal optics.
Muliple scattering and localization of light. Powder colors.
Quasiparticles in solids. Holes, excitons, polaritons.
Optical properties of amorphous and disordered solids.

Basic quantum confinement effects. Their optical manifestations. Analogies of quantum dots and molecules.
Spontaneous emission of light by quantum systems. Role of density of em-modes (photon states).
Spontaneous emission and scattering in model mesoscopic structures: microcavities, photonic crystals, metal-dielectric composites.
Nonlinear optics of semiconductors and nanostructures.
Modern techniques of optical experiment.

2. Laboratory (practical work) not applicable

3. Material available

Type	**Languages/format**
Not applicable	

4. Prerequisites:
Basic university courses in quantum mechanics, atomic physics, optics.

Study Times

Type	Hours
Lectures	40
Excursions to optical research institutes	6
Excursion to optical industrial site	4
Self study and report writing*	20

**These times are rough estimates of the work by a typical student.*

Assessment – n/a

%	Type	Details
	Oral examination	

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
C. Klingshirn	Semiconductor Optics	Springer	1995		USD 60	B
S.Gaponenko	Optical Properties of Semiconductor Nanocrystals	Cambridge University Press	1998, 2005	0-521-58241-5	USD 40	B
Joannopoulos J D, Meade R D, Winn J N	*Photonic Crystals*	Princeton Univ. Press,	1995		USD 50	B

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Applied Photonics and Nanophotonics

Advanced Optoelectronics: Innovative Designs

Partner name, place and country	**Bilkent University, Ankara, Turkey**
Partner number	**8**

General information

Institute:	Bilkent University
Target group	Junior graduates/senior undergraduates
Course code	Phys 468-568, EE 481-581
Language of Instruction	English
ECTS Credits:	
Period	September-January (alternating years)
Course website	http://www.bilkent.edu.tr/~volkan/
Lecturer/contact person	Hilmi Volkan Demir
e-mail address	volkan@bilkent.edu.tr

Description of the Course

Aims:

To study and understand state-of-the-art semiconductor optoelectronic and nanophotonic devices, their operating principles, designs, uses, strengths, and weaknesses, with a strong emphasis on innovation.

Objectives:
To inspire innovation by walking students through innovation stories and case studies in advanced optoelectronics and nanophotonics, to challenge students to invent new devices and/or improve the designs of existing devices, and to practice scientific paper writing and review processes.

Course Structure:

1. Lectures
Review of physics of optoelectronic devices including heterostructures, optical quantum processes (optical absorption, emission and refraction in bulk and quantum structures), and junction theory. Light emitting diodes. Semiconductor optical detectors. Optical modulators. Laser diodes. Solar cells. Photonic switches. Quantum devices. Integrated photonic devices. Nano-scale photonic devices. Innovative optoelectronics.

2. Laboratory (practical work)
Design and simulation work on each device type or functionality studied in the lecture.

3. Material available

Type	**Languages/format**
Handouts, presentations, papers	English/hardcopy

4. Prerequisites:
Basic knowledge of solid state physics, applied quantum mechanics, EM and circuit theory.

Study Times

Type	Hours
Lectures and tutorials/seminars	3x14=42 hours
Design work	2x14=28 hours
Self study and report writing*	42 + 2x28 hours

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
40	Project	(project proposal, paper submission, paper review, paper revision)
20	Midterm	(open book, in class)
20	Midterm	(take-home)
20	Portfolio	(design work weekly, survey daily in class)

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
David A. B. Miller	Advanced Optoelectronics	Stanford University	2004			B
Shun Lien Chuang	Physics of Optoelectronic Devices	John Wiley & Sons	1995	ISBN: 0-471-10939-8		C
Jasprit Singh	Semiconductor Devices	John Wiley & Sons	2001	ISBN 0-471-36245-X		C

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Microfluidics and Lab-on-a-chip Systems

Partner name, place and country	**LPN/CNRS, Marcoussis, France**
Partner number	**25**

General information

Institute:	Ecole Normale Supérieure of Paris
Target group	ENS master students
Course code	-
Language of Instruction	French
ECTS Credits:	-
Period	April-May (every year)
Course website	-
Lecturer/contact person	Prof. Yong Chen
e-mail address	yong.chen@lpn.cnrs.fr

Description of the Course

Aims:
To gain a complete, new and multi-disciplinary knowledge base on microfluidics.

Objectives:
This course was prepared for the master students of the *Ecole Normale Supérieure* of Paris for a quick acquisition of scientific and technologic know-how of microfluidics and lab-on-a-chip systems. It aims to learn not only the microfluidic technologies but their explorations in advanced research areas based on advanced studies.

Course Structure:

1. Lectures

- General introduction to microfluidics and lab on chip systems (general context, history, state of the art, and application perspectives)
- Physics of microfluidics (wetting, electro wetting, hydrodynamics and thermal effect at micro scales, diffusing properties, electro-osmoses, electrophoresis, dielectrophoresis, microfluidics related micro optics, magnetism and micro-mechanics),
- Conventional and non-conventional nanofabrication technologies for the realisation of microfluidic devices (optical lithography, electron beam lithography, focus ion beam lithography, nanoimprint lithography, soft lithography, micro-contact printing, pattern transfer techniques including thin film deposition, wet and dry etching, device assembling, etc),
- Microfluidic techniques (flow control, surface functionalization, droplet, particles handing, mixing, micro reactor, separation, and detection including intracavity laser absorption and electrochemical and nano-pore analysis),
- Application examples (cell culture and stem cell differentiation, cell sorting and purification, cell manipulation including electroporation, patch clamp, lying,

mechanic and chemical stimuli, protein crystallization, DNA separation, PCR an dRT-PCR, neuro-chips and tissues engineering possibilities).

2. Laboratory (practical work)

A 4 hours laboratory work is programmed at the end of the courses, including

- Project definition
- Optical lithography patterning for the mould fabrication,
- Nano-imprint lithography and soft lithography for structure fabrication
- Microfluidic device assembling including plasma surface activation and thermal bonding
- Characterisation of the fabrication micro and nanostructures as well as observation of microfluidic behaviours in the fabrication device (example: laminar flow, flow focusing, molecular diffusion, micro thermal effect, electrophoresis for DNA stretching).

3. Material available

Type	Languages/format
Handouts (not available on the Internet)	English

4. Prerequisites:

Advanced courses in physics and material science and very good culture in chemistry, biology and nanotechnologies.

Study Times

Type	Hours
Lectures and tutorials/seminars + ½ day visit to an optoelectronic industry	20 hours
Laboratory work	1x4

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Written examination	½ hour literature presentation

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Optical Fiber Communication Systems

Partner name, place and country	**Koc University, Istanbul, Turkey**
Partner number	

General information

Institute:	**Koc University**
Target group	Senior undergraduates, graduates
Course code	ECOE 524
Language of Instruction	English
ECTS Credits:	
Period	February-June every year, 15 weeks
Course website	
Lecturer/contact person	Alper Demir
e-mail address	aldemir@ku.edu.tr

Description of the Course

Introduction to optical fiber communication systems. Guided-wave optics, dielectric waveguides and optical fibers: transmission properties, attenuation, chromatic dispersion, polarization-mode dispersion, nonlinearities, solitons. Optical amplification: erbium-doped fiber amplifiers, Raman amplification. Lasers and photo-detectors. Analog and digital modulation schemes, direct detection, coherent homodyne and heterodyne modulation and detection. Modulator, transmitter and receiver design. Multichannel transmission, dense and ultra-dense wavelength division multiplexing. Optical fiber communication links: transmission impairments, noise, nonlinearities, dispersion compensation and management, modeling and simulation. Optical fiber communication networks: Cable TV, metro, long-haul, ultra-long haul, terrestrial and submarine links. All optical networks, optical interconnect in high-speed VLSI circuits, modules, and computers.

Course Structure:

1. Lectures

2x75 mins/week, 15 weeks

2. Laboratory (practical work)

3. Material available

Type	Languages/format
Lecture notes, slides	English, PDF

4. Prerequisites:

Signals & systems (Fourier analysis), electromagnetic waves, random processes, basic telecommunications concepts as covered in undergraduate courses on signals & systems, electromagnetics and telecommunications.

Study Times

Type	Hours
Lecture attendance	2.5 hrs/week, 37.5 hrs total
Self study and report writing*	7.5 hrs/week, 112.5 hrs total

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
50	Term paper/project	
50	Homework assignments	

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
G. P. Agrawal	Fiber-Optic Communication Systems, 3rd edition	Wiley	2002			B

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Biophotonics

Introduction in Biophotonics

Partner name, place and country	**ICFO-Institut de Ciències Fotòniques, Barcelona, SPAIN**
Partner number	**3**

General information

Institute:	ICFO-Institut de Ciències Fotòniques
Target group	PhD Students
Course code	
Language of Instruction	English
ECTS Credits:	30 hours
Period	April-May
Course website	http://www.icfo.es/index.php?section=teaching2&lang=english
Lecturer/contact person	Prof. Dmitri Petrov, Prof. N. van Hulst, Dr. Pablo Loza
e-mail address	dmitri.petrov@icfo.es

Description of the Course

Aims:
The course will be centered on several main topics covering the application of optics in study of biological objects like cells, tissues. In particular, in this course we suppose to consider the ability of a light beam to exert mechanical forces on objects like living cells and to manipulate its position. We also consider techniques of nonlinear microscopy that permit gain new information on living cells that can not be achieved by conventional microscopy. The microscopy beyond the diffraction limit, optics at the nano-metric scale, and different techniques as scanning probe microscope, STM, AFM, NSOM are included in the course.
Background will be giving first on theory of the physical processes involved, as well as on experimental tools needed for realization the techniques. We propose that during the course students will perform several basic experiments at the ICFO lab that help to understand more deeply physical mechanisms involved in the techniques.

Objectives:
To give students an up-to-date introduction in different optical techniques used in study of living cells and single bio-molecules.

Course Structure:

1. Lectures
1. Introduction: why experimentalists working in different areas need a tool to move microscopic objects and new high resolution imaging techniques.
2. The mechanical action of light – theory of optical trapping.
3. Experimental aspects of optical trapping.

4. Combining the optical trap with Raman spectroscopy and fluorescence.
5. Applications of optical trapping in Physics, Chemistry, and Biology.
6. Experiments in a lab I.
7. Molecular fluorescence and nonlinear optics.
8. Microscope, image acquisition and fluorescence imaging.
9. Nonlinear microscopy.
10. Imaging of living cells.
11. Microscopy beyond the diffraction limit, optics at the nano-metric scale.
12. Scanning probe microscope, STM, AFM, NSOM.
13. Single molecule biophysics.
14. Experiments in a Lab II.

2. Laboratory (practical work)

3. Material available

Type	**Languages/format**
ICFO- web page https://www.icfo.es/courses/biophotonics2006/html/index.html	English

4. Prerequisites:

Study Times

Type	**Hours**
Self study and report writing*	

**These times are rough estimates of the work by a typical student.*

Assessment

%	**Type**	**Details**
	Assistance at the lectures	
	Elaboration, presentation, discussion and defence of a small project	

Comment:

Recommended Books

Authors	**Title, edition**	**Publisher**	**Year**	**ISBN**	**Cost**	**Code**
Paras N. Prasad.	Introduction to Biophotonics.	Wiley Interscience (USA)	2003	0-471-28770-9		

B. Herman,	Fluorescence Microscopy.	Springer (UK)	2001	0-387-91551-6.
K. O. Greulich,	Micromanipulation by light in Biology and Medicine,	Birkhauser	1999	
Bohren C.F., Huffman D.R.	Absorption and scattering of light by small particles	Wiley	1983	

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Semiconductors

Advanced Semiconductor Materials at KTH

Partner name, place and country	**KTH, Royal Institute of Technology, Stockholm, Sweden**
Partner number	**22**

General information

Institute:	KTH, Royal Institute of Technology, Stockholm, Sweden
Target group	Senior undgraduates/Junior graduates
Language of Instruction	English
ECTS Credits:	7.5
Period	January – March (every year)
Course website	http://www.it.kth.se/courses/2B1700/
Lecturer/contact person	Prof. Sebastian Lourdudoss
e-mail address	doss@imit.kth.se

Description of the Course

Aims:

To gain knowledge on the unique properties and fabrication of compound semiconductors and their heterostructures for devices - To get introduced to the concepts on organic semiconductors

By giving the practical knowledge which a semiconductor industry may desire, this course aims to complement other courses on semiconductors dealing with mainly theoretical aspects

Objectives:

Distinguish between direct and indirect bandgap semiconductors and exploit their transport and optical properties - Understand the various bulk and epitaxial techniques used to fabricate the compound semiconductors - Appreciate the use of heterostructures and bandgap engineering in the fabrication of several optical and electronic components - Gain some basic knowledge on organic semiconductors

Course Structure:

1. Lectures

General Introduction to the Course, Choice of semiconductors (elemental and compound), Applications, Crystal Structures, Crystal Planes, Polar axis, Defects - Thermodynamics relevant to crystal growth - Bulk crystal growth, Liquid phase epitaxy (LPE) - Vapour Phase Epitaxy (VPE), Metal Organic Vapour Phase Epitaxy (MOVPE), Molecular Beam Epitaxy (MBE) - Electrons in metals, insulators and semiconductors - Important semiconductor bandstructures - Doping of semiconductors - Modification of bandstructure by alloying, heterostructures and strain - Quantum Wells, Quantum Wires, Quantum Dots - Carrier dynamics in semiconductors and optical properties - P-N junctions - Semiconductor junctions with metals and insulators - Electronic components – Optical components - Processing techniques such as dielectric deposition, lithography, etching and metallization - Organic semiconductors

2. Laboratory (practical work)

1) MOVPE growth of a GaInAsP/InP structure, 2) PL and X-ray analysis of the above structure, 3) Hall effect measurements and 4) Laser characterisation

3. Material available

Type	Languages/format
Handouts (available on the Internet)	English

4. Prerequisites:

Basic courses on solid state physics, materials science and quantum mechanics.

Study Times

Type	Hours
Lectures and tutorials/seminars + ½ day visit to an optoelectronic industry	34 hours
Laboratory work	4x4
Self-study and report writing*	34x2 + 4x4

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
80	Written examination	5 hours of written examination
20	Proper lab report	4 laboratory reports jointly written by a group of 4-5 students

Comment: Pass threshold is 60% in the written examination *and* an approved lab report

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Jasprit Singh	Semiconductor Devices	John Wiley & Sons	2001	ISBN 0-471-36245-X	ca 90 €	B

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Advanced Semiconductor Materials at Tyndall

Partner name, place and country	**Tyndall National Institute**
Partner number	**1**

General information

Institute:	University College Cork
Target group	Final year undergraduate/ Postgraduate
Course code	UE4006
Language of Instruction	English
ECTS Credits:	
Period	8 weeks
Course website	
Lecturer/contact person	Brian Corbett/Aidan Quinn
e-mail address	bcorbett@tyndall.ie

Description of the Course

Aims:
Introduction to nanoelectronics and photonics

Objectives:

Distinguish between direct and indirect bandgap semiconductors and exploit their transport and optical properties - Understand the various bulk and epitaxial techniques used to fabricate the compound semiconductors - Appreciate the use of heterostructures and bandgap engineering in the fabrication of several optical and electronic components - Gain some basic knowledge on organic semiconductors

Basic understanding of transport in low dimensional systems;
Understanding physics and basic principle of key photonic devices: lasers, LEDs, RCLEDs, VCSELs;
Introduction to emerging technologies;

Course Structure:

1. Lectures
Nanoelectronics: Introduction to low dimensional physics; transport in low dimensional systems; heterostructure devices; quantum device operation. Nanophotonics: Band structure engineering for photonic devices; photonic device fabrication technologies; survey of key devices: LEDs, RCLEDs, VCSELs, microdisks, quantum dot devices, single photon devices. Emerging technologies: Mesoscopic physics: wave function coherence, tunnelling; devices based on ballistic transport, single charge tunnelling, resonant tunnelling; fabrication and assembly at

the nanoscale; nanoscale visualisation and characterisation; molecular scale electronic devices.

2. Laboratory (practical work)

Not included

3. Material available

Type	Languages/format
Lecture slides	English/pdf

4. Prerequisites:

Study Times

Type	Hours
Lectures	8+16

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Written examination	1 hour written examination

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
H.C.Casey and M.B.Panish	Heterostructure Lasers	Academic				
G.P.Agrawal and N.K.Dutta	Semiconductor Lasers	van Nostrand Reinhold				

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Physics of Semiconductors II

Partner name, place and country	**UPavia, University of Pavia, Italy**
Partner number	**24**

General information

Institute:	University of Pavia, Department of Physics "A. Volta"
Target group	Junior graduates, PhD students
Course code	None
Language of Instruction	Italian (English if required)
ECTS Credits:	5
Period	March-May (every year)
Course website	None
Lecturer/contact person	Prof. Lucio Claudio Andreani
e-mail address	andreani@fisicavolta.unipv.it

Description of the Course

Aims:
The course, which could also be entitled "Semiconductor nanostructures and photonic systems", aims at introducing the basic principles and the variety of phenomena associated to electronic and photonic confinement in one or more dimensions.

Objectives:
Achieving a basic knowledge of semiconductors nanostructures with electronic confinement in 1D, 2D, 3D. Knowing the basics of photon confinement and of the analogies with electronic confinement. Understanding the physical principles underlying the most common semiconductor-based devices (e.g. HEMT, semiconductor laser, quantum-cascade laser, resonant tunnelling devices, VCSELs).

Course Structure:

1. Lectures
Ab-initio electronic structure, density-functional theory, band discontinuities and band offsets at semiconductor interfaces – Electronic states in two-dimensional systems: envelope function theory, quantum wells, superlattices, modulation doped interfaces – Multiband **k•p** theory, valence bands, Luttinger Hamiltonian, heavy and light holes – Radiative properties: absorption and emission, van Roosbroek-Shockley, model, interband and intersubband transitions in quantum wells – Excitons and polaritons in bulk semiconductors and in quantum wells – Tunnelling: Esaki tunnel diode, negative differential resistance, transfer-matrix method, resonant tunnelling in double-barrier configuration – Effects of electric fields: Franz-Keldysh, quantum confined, Bloch oscillations, Wannier-Stark ladders, Effects of magnetic fields: Landau levels, Shubnikov-de Haas effect, magneto-optics – Classical and Quantum Hall effect:

magnetoconductivity tensor, integer QHE, fractional QHE – Quantum wires: electron confinement, excitons, conductance quantization – Quantum dots: electron confinement, excitons, Coulomb blockade – Photon confinement: distributed Bragg reflector, planar semiconductor microcavities, dielectric waveguides and 3D microcavities (micropillars, microdisks), Q-factor, spontaneous emission and Purcell effect, photonic crystals and nanocavities.

2. Laboratory (practical work)
none

3. Material available

Type	Languages/format
Handouts	Italian

4. Prerequisites:
Basic courses in solid state physics, bulk semiconductors (Semiconductor Physics I), electromagnetism and optics

Study Times

Type	Hours
Lectures	36
Self study and report writing*	80

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
100	Oral examination (1h)	Student chooses 5 chapters out of 10

Comment: Students usually choose the first chapters, which are the basic ones

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
P.Y. Yu, M. Cardona	Fundamentals of Semiconductors, 3rd edition	Springer-Verlag	2004	3540413235	€ 50	B
J.H. Davies	The physics of low dimensional semiconductors	Cambridge University Press	1998	052148491X	€ 40	D

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Imaging

Modern Imaging Methods

Partner name, place and country **Chalmers University of Technology, Göteborg, Sweden**

Partner number **19**

General information

Institute:	Applied Physics, Chalmers
Target group	Senior undgraduates/Junior graduates
Course code	TIF 030 or FIM 150
Language of Instruction	English
ECTS Credits:	5
Period	Jan-March every year
Course website	http://www.student.chalmers.se/sp/course?course_id=7927
Lecturer/contact person	Mikael Käll/Eva Olsson/Christer Svensson
e-mail address	kall@fy.chalmers.se

Description of the Course

Aims:
To understand the principles and get some hands on experience with advanced optical microscopy, electron microscopy (SEM and TEM) and scanning probe microscopies (AFM and STM)

Objectives:
The student should have understood the basics of image formation in the three microscopy methods, their different limitations when it comes to e.g resolution, and some their main application areas.

Course Structure:

1. Lectures
12 lectures on the principles behind the different microscopy methods

2. Laboratory (practical work)
4 laborations (4 hours each) on optical microscopy, SEM, TEM and STM

3. Material available

Type	**Languages/format**
handouts	English

4. Prerequisites:

Study Times

Type	**Hours**
Lectures and tutorials	24
Laboratory work	4x4
Self-study and report writing	80

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
70	Written exam	5 hours exam
30	4 lab reports + 10 hand-ins (problem solving)	Lab-reports are obligatory, hand ins give bonus on exam

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Recent research articles						

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Masters Programmes

MSc in Photonics

Partner name, place and country	**Tyndall National Institute, Cork, Ireland**
Partner number	**1**

General information

Institute:	University College Cork
Target group	Post Grads
Course code	
Language of Instruction	English
ECTS Credits:	-
Period	12 months
Course website	
Lecturer/contact person	Frank H Peters
e-mail address	F.Peters@ucc.ie

Description of the Course

Aims:
To provide specialist master's level education and training in photonics to physicists, electrical engineers, materials scientists, and other technical specialists or managers involved or intending to become involved in photonics research, the photonics industry and related activities

Objectives:
To understand the physics and engineering of photonic materials, devices, systems and applications, and to develop the necessary professional skills for an entry level career in photonics research or industry

Course Structure:
Students must take al modules from Group 1-3.

Group 1: Photonic Materials

PY6051	Photonic Materials, Solid State Physics
PY6052	Photonic Materials, Growth, Processing and Characterization

Group 2: Photonic Devices

PY6053	Photonic Devices, Lasers and Amplifiers
EE6055	Photodetectors and Photodetection

Group 3: Photonic Systems

PY6054	Photonic Systems, High Speed & Integrated Photonics

PY6056	Photonic Systems, Fibre Optics Communications

In addition, students will be assessed in the following modules:

PY6080	Preliminary thesis research study (P1, P2)
PY6090	MSc Mode 2 research project and thesis (subject to qualification)

1. Lectures

Module	**Lectures**	**Content**
PY6051	36	Periodic structures, lattices and reciprocal lattices. Thermal properties of free electrons. Electronic states in periodic structures. Electron transport theory. optical exciation of semiconductors and insulators, direct and indirect band-gaps, optical properties, the complex dielectric function, dispersion, absorption and gain, excitons, polaritons. Photonic Band Gaps.
PY6052	36	Physical and chemical properties of III-V compound semiconductors GaAs and InP; growth of GaAlAs, InGaAsP by MOVPE, MBE; characterization of materials and junctions: photoluminescence, Hall effect, microscopy, SIMS. Junction device physics review and simple process sequences for laser diodes. Processing: wafer clean and etch, wet and dry etching, photolithography with etch and liftoff, e-beam lighography outline, device isolation Thin film deposition: physical and chemical methods, characterization, metallization and Ohmic contacts. Degradation of III-V semiconductor devices: dark defects, facet or junction degradation, catastrophic damage. Introduction to reliability physics and statistics, design of lifetests, accelerated aging and stress testing. Introduction to silicon based optical MEMs devices and processing.
PY6053	36	Semiconductor gain. Lasers and amplifiers, static and dynamical properties, lasing modes and linewidth. Methods of test and measurement. Computer simulation of laser diodes and semiconductor optical amplifiers
EE6055	36	Optical absorption in semiconductors. Carrier transport. Physics of p-n junctions. Design of photodiodes, including MSM, p-n, and p-i-n photodiodes. Carrier impact ionization, noise, multiplication gain and avalanche photodiodes. Geiger-mode devices for photon counting, including photomultiplier tubes, microchannel plates and semiconductor photon counters. Imaging detector devices such as charge-coupled devices and APD arrays. Photodetection techniques, such as direct and coherent detection; balanced detectors. Solar cell structures and principles of operation. Infra-red and thermal detectors. Detector circuits and applications.
PY6054	36	Optical and microwave waveguides. Second Harmonic Generation. Optical modulators based on bulk and quantum well absorption regions. Design of high speed detectors, lasers and modulators. Planar waveguide devices including MMI (multimode interference) combiners, AWGs (arrayed waveguides) and Echelle gratings. Integrated Photonics.

PY6056	36	Fibre optical waveguides. Nonlinear propagation: phase Modulation, 4 wave mixing, polarization mode dispersion. Linear propagation: dispersion compensation, dispersion maps, linear crosstalk, problems in real networks, Add-Drop Multiplexing. Modulation formats optical networks (SONET/SDH, Packet switching).

2. Laboratory (practical work)

Modules PY6051, PY6052, PY6053, EE6055, PY6054, PY6056 will involve laboratory work

3. Material available

Type	Languages/format

4. Prerequisites:

none

Study Times

Type	Hours
Lectures x 6 modules	36 hours

**These times are rough estimates of the work by a typical student.*

Assessment

%	Type	Details
66.7	Group 1-3 Written – End of year Continuous Assessment (in-term assigned work, midterm exam and laboratories)	100 marks for each module 100 marks for each module [pass mark of 40% (480/1200), with no module below 30%]
5.5	PY6080 – Continuous assessment	Students must obtain 60%
27.8	PY6090 – Continuous assessment	Students must obtain 50%

Comment:

Recommended Books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code

Codes: A = Compulsory; B = Strongly Recommended; C = Recommended; D =wider reading

Erasmus Mundus Master Programmes

MSc in Photonics

http://www.master-photonics.org/index2.html

MSc in Molecular nano- and bio-photonics for telecommunications and biotechnologies

http://www.ens-cachan.fr/monabiphot/

MSc in Nanoscience and Nanotechnology

http://www.emm-nano.org/indexnano.htm

Master's and Ph.D Thesis Support

Thesis and internship in Optical Communications and related technologies

Partner name, place and country	**CoreCom, Milan, Italy**
Partner number	**34**

General information

Institute:	CoreCom, Milano, Italy
Target group	Senior undergraduates(in projects like ERASMUS or TIME or alike) or junior graduates
Course code	------
Language of Instruction	English
ECTS Credits:	-------
Period	To be defined
Course website	NONE
Lecturer/contact person	Dr. Silvia M. Pietralunga
e-mail address	pietralunga@corecom.it

Description

Aims:

The educational task of CoreCom is to support students during their thesis (both Master's and Ph.D.), mainly by providing access to technological and laboratory facilities. At CoreCom Labs, students (undergraduate/graduate) can undergo experimental and theoretical training related to Optical Communications Systems (numerical simulation and experimental validation on long-haul high bit-rate optical transmission: innovative modulation formats, dispersion management, non-linear effects…), integrated optics passive devices and optical circuits, slow-wave structures (design, test), technology of nanopatterning and lithography, thin films, optical characterizations etc.
Students are involved in the research projects and they are given well defined and specific tasks and collaborate with their tutor, having access to CoreCom's facilities.

Objectives:

The training can be part of a Master's thesis (in this case, to be defined as in the frame of either ERASMUS or TIME program or alike) or part of a Ph.D. thesis. We also welcome young researchers (post-graduates) to acquire training-on-the-job in our site.

Prerequisites:

Master degree lever in either Physics or Chemistry or Optical Engineering or Electronics Engineering or Communication Engineering.

Funding

Theses are not funded by CoreCom. Training costs (tutoring, lab facilities etc.) involved in the internships are met by CoreCom but neither salary nor other expenses are provided by CoreCom.

Summary of Courses

Country	Institution	Course Title	Masters	PhD
Ireland	University College Cork – (Tyndall National Institute)	Advanced Semiconductors Materials	√	√
	University College Cork – (Tyndall National Institute)	Msc in Photonics	√	
	University College Cork – (Tyndall National Institute)	Introduction to Lasers and Photonics		
Italy	European Laboratory for Non-Linear Spectroscopy	Physics of Nano Structures	√	√
	Universita degli Studi di Pavia	Physics of Semiconductors II	√	√
	Corecom- Consorzio Ricerche Elaborazione Commutazione Ottica Milano	Thesis and internship in Optical Communications and related technologies	√	√
Spain	Fundació Privada Institut de Ciències Fotòniques	Introduction in Biophotonics		√
	Fundació Privada Institut de Ciències Fotòniques	Experimental Quantum Optics and Quantum Information		√
	Fundació Privada Institut de Ciències Fotòniques	Photonics from Micro to Nano-scale		√
	Consejo Superior de Investigaciones Centificas - ICMM	Introduction to Research in Optics		√
	Universita Politecnica de Catalunya	Introduction to Photonics		√
Lithuania	Vilnius Pedagogical University	Nanophotonics		
Turkey	Bilkent Universitesi	Advanced Optoelectronics: Innovative Designs	√	√
	Koc University	Optical Fiber Communication Systems	√	√
France	Centre National De La Recherche Scientifique	Microfluidics and Lab-on-a-chip Systems		
	Universite Montpellier 2	Modelisation and Simulation in Photonics		
	Ecole Normale Superieure Cachan	Molecular Nanophotonics	√	√
Germany	Technical University of Dresden	Introduction to Nanoscience	√	√
	Universitaet Dortmund	Modern Optics	√	√
Belarus	Institute of Molecular and Atomic Physics	Optics of Condensed Matter and Nanostructures		
Sweden	Chalmers Tekniska Hoegskola Aktiebolag	Modern Imaging Methods		
Sweden	Kungliga Tekniska Hogskolan	Advanced Semiconductors Materials	√	√
Israel	The Weizmann Institute of Science	Nanoscience		√

Other training opportunities

Vilnius PhOREMOST 2nd ANNUAL WORKSHOP
"ADVANCES IN NANOPHOTONICS"

September 26-28, 2006
Vilnius, Lithuania

The PhOREMOST workshop Advances in Nanophotonics will be held in the Reval Hotel Lietuva in Vilnius on 26-28th September. This workshop will be held in conjunction with the PhOREMOST Year 2 General Assembly Meeting.

In addition to the scientific workshop a special session aimed at young researchers will held on Wednesday 27th. Guest speakers include Jean Luc Dumont from Principiae (www.principiae.be) and Elke Van der Brandt from the NEMO Network of Excellence.

Young Researcher Poster Session: Cash prizes for winner and 1 runner up.

We encourage all partners to send at least 2 researchers per team.

Son et Lumière: from Microphotonics to Nanophononics, Summer School

16-28 Octobre

Institut d'Etudes Scientifiques de Cargèse

The school "Son et Lumière: from microphotonics to nanophononics" will focus on an emerging subject: nanophononics. This involves the control of the spectral and spatial distribution of GHz and THz acoustic phonons in nanostructures, and the modification of the electron-phonon and photon-phonon interactions in electronic and optoelectronic devices.

For more information; **http://www.cab.cnea.gov.ar/sonetlumiere/index.htm**

School on Quantum Electronics: Advances on Nanophotonics

June-July 2007

Ettore Majorana Foundation and Centre for Scientific Culture Erice, Sicily
Prof. S. Martellucci：

Directors of the Course: C. Sibilia UR-DE, D.S. Wiersma LENS

There has been an increasing interest, in recent years, in nanophotonics. Nanophotonics is a very broaden field, having fascinated aspects both from a fundamental point of view and with regard to future applications in photonic devices and materials. The scope of the school is to introduce participants to concept, methods, applications and the state of the art in nanophotonics. The school will focus on both the theoretical and experimental aspects of the current research in this field, with an eye to applications.

Useful web links

Specific Courses

http://www.owlnet.rice.edu/~elec603/EE603CourseDescription.htm

http://www.physics.usyd.edu.au/cudos/nanophotonics-course/index.html

http://www.spie.org/app/Education/index.cfm?fuseaction=CDRomdetail&product_id=502626

http://www.nanohub.org/courses/nanophotonics

http://www.com.dtu.dk/English/Education/Courses.aspx?coursecode=34051

http://www.ee.duke.edu/~yoshie/teaching/ece299_nanophotonics/V1.pdf#search=%22nanophotonics%20course%22

http://www.inano.dk/sw218.asp

The 1st European Topical Meeting on Nanophotonics and Metamaterials

http://www.nanometa.org/

www.phoremost.org