Institut d'Optique - Third Year - Palaiseau 2011-2012

Photonics Function and integration

Coefficient : 3

Module : **Optical Sciences** Hours : **30,0 h**

Person in charge : **Mr Henri BENISTY**

Teachers :

Method of evaluation :
Key words : Photonics Function and integration

Aims

The first aim is to explicit the operation principles and the required technologies of photonic semiconductor devices, in an integration perspective. The case of the current mature technologies of optical telecommunication in current networks is taken as a basis in this respect, with a look to emerging trends to be deployed soon. Expliciter les principes de fonctionnement et les technologies des dispositifs photoniques semi-conducteurs, dans une perspective d'intégration. The aim of the final part of the course is to present the methods to treat signals by electro-optical or acousto-optical means, following their current deployment beyond telecom in micro-wave photonics and in lidars for instance.

Course structure

1) Wave coupling, semiconductor emblematic devices (H. Benisty):

We will start by a reminder of the description of wave coupling and of semi-conductors and quantum wells.(6h)
We will then study as a general basis the application of these concepts through a couple of emblematic devices (QW laser, DFB, VCSEL,QD laser)

2) The performance – technology cycle of telecom devices (Béatrice Dagens, IEF)

• We revisit in some detail the individual and integrated devices, situating them in the context of telecom networks, and showing their impact on the overall performance

• We next consisder the « elementary » case of the semiconductor laser, in order to progressively introduce the underlying physical principles of all optoelectronic devices, their fabrication technology, the principles, and degrees of freedom in their design rules. This will lead us to the integration of devices into « PIC », Photonic Integrated Circuits, and the additional compromises on devices related to the whole technological system. We will give a hint of alternative technologies (glass, LiNbO », SOI) and at PIC developed for emerging non-telecom applications such as bioplasmonics. All these basis will allow us to deepen the physics behind the operation and characterisation of key optoelectronic devices as listed above

3) Telecom and Datacom devices : emerging trends (Guang-Hua DUAN, 3-5Lab) (COULD BE IN ENGLISH, pls inform)

• In this part, several trends observed in the last few years in telecom and datacom domains will be treated : wavelength division multiplexing and wavelength routing, new modulation formats, and « silicon photonics », the integration of photonics onto a silicon platform. In the part on wavelength routing and multiplexing, emphasis will be on wavelength tuneable sources, and wavelength manipulation (filtering, routing, translating,…)

• About the new modulation format, we shall detail the required phtoonic circuits, using for instance a combination of several Mach-Sehnder interferometers. On Silicon photonics, the various building-blocks will be explained : laser, modulator, photo-detetcors, passive Si-based guides, etc. Several integration exemples in datacom and telecom will illustrate this part.

4) Electro- and Acosuto-optical signal treatment, micro-wave and lidar applications (D. Dolfi et J.P. Huignard -TRT Thales)

• Electro-optic and acousto-optic phenomena and applications :Induced birefringence in crystals and ceramics, operation in free space and guided modes, light modulators for optical telecommunications, acousto-optic and electro-optic laser beam switching and scanning

• Optical and electro-optical properties of liquid crystals:
Liquid crystal phases, Optical and EO properties,Technology of liquid crystal cells

• Applications : display, light valves, nonlinear optics
Comparisons with other technologies, Applications of wave mixing in materials, Volume holography; Materials : photorefractives, gain media, Brillouin scattering ; Application of wave mixing to image amplification, and wave conjugation, Applications to signal processing, laser beam control, and thermal effect compensation,

• Opto-electronic links, from telecommunications to radars, Opto-electronic links main characteristics (gain, noise figure, linearity, dynamic range): from system requirements to component physics; Applications to opto-electronic processing of radar signals (phased array antenna, agile filtering, correlation, spectrum analysis, oscillators, high precision clocks, ..); Photonic generation and detection of millimetre-wave and THz signals ;Basics of lidar systems

Lecture notes

Copie of the slides of the different courses

Bibliography

- The principles of nonlinear optics, Y.R. Shen (Wiley-Interscience)
- Wave Mechanics applied to semiconductor heterostructures, G.Bastard (Springer) –
- Quantum semiconductor Structures : Fundamentals and applications, C. Weisbuch and B. Vinter (Academic Press) -
- H. C. Casey, Jr. and M. B. Panish, « Heterostructure Lasers », Academic Press, 1978 –
- G. H. B. Thomson, « Physics of semiconductor Laser Devices », John Wiley, 1980
- Govind P. Agrawal, Niloy K. Dutta, « Semiconductor Lasers », Van Nostrand Reinhold, 2nd ed. 1993,
- Philippe Brosson, « Semiconductor lasers and integrated devices », Les Houches, summer school on « lasers and applications », June 2000,

Prerequisites

Basic Laser diode (Fabry-Perot style), basics of gain media and optoelectric media, basis of optical telecommunications (fibers, modes of fibers, transmission rates)