Photonics and Optical Communication

(Course Number 320352)
Spring 2007
Instructor: Dr. Dietmar Knipp

Course Syllabus

Objectives:

The course will provide you with the fundamental concepts in photonics, which have increasing applications in the area of information technology and communication, healthcare and life science, optical sensing, lightning, energy and manufacturing. The course will focus on the applications in optical communication, fiber optical communication and communication systems. During the first part of the course the interaction of photons and matter, the propagation of light in waveguides and optical fibers, the operation principles of light emitting diodes, semiconductor lasers, detectors, and optical modulators will be discussed. In the second part of the course the operating principles of optical communication systems will be discussed including wavelength division multiplexing, optical amplification and integrated optical systems.

Course Topics:

The course is divided in 10 modules.

1. Introduction to Photonics and Optical Communication (2 sessions)
2. Review of optics (5 sessions + HW)
3. Optical waveguides (2 sessions)
4. Optical fibers (3 sessions + HW)
5. Optical sources and transmitters (3 sessions + HW, talks)
6. Optical detectors and receivers (1 sessions + HW, talks)
7. Lightwave systems (1 sessions)
8. Optical Devices / Optical Amplifiers (1 sessions)
9. Optical MUX and DEMUX (1 sessions + HW)
10. Systems design (2 sessions)
Short descriptions of the modules:

1. **Introduction to Photonics and Optical Communication**
   This module will give an overview of photonics and its applications in different areas like information technology, communications, healthcare, life sciences, optical sensing, lighting, energy and manufacturing. A historical introduction into communication and optical communication systems will be given. The evolution of lightwave systems will be discussed before the basics of optics will be reviewed.

2. **Review of optics**
   The basics of optics will be covered including: Interference, diffraction, coherence and polarization.

3. **Optical waveguides**
   The module will discuss the propagation of light in optical waveguides.

4. **Optical fibers**
   The module covers the propagation of light in multimode and single mode fibers, coupling into and out of a fiber, attenuation, group velocity, dispersion, and optical non-linearities.

5. **Optical sources and transmitters**
   In this module the physics of light emission and amplification in a semiconductor, light emitting diodes, semiconductor lasers (edge emitting lasers and vertical cavity surface emitting lasers (VCSELs)) will be described.

6. **Optical detectors and receivers**
   This module covers the basic concepts of light detection of light including photoconductors, photodiodes and receiver systems.

7. **Lightwave systems**
   A summary of important concepts of digital optical communication including time-division multiplexing (TDM) and wavelength division multiplexing (WDM) will be given.

8. **Optical Devices**
   Different optical devices, which are essential for an optical network like optical amplifiers, polarization control devices, optical isolators, optical filters and diffraction gratings, modulators and switches, will be discussed.

9. **Optical MUX and DEMUX**
   In order to transmit data from point to point the different channels have to be merged on the transmitter side and separated on the receiver side. In this chapter the operating principle of multiplexors and demultiplexors will be discussed.
10. **Optical systems design** This module covers the dispersion in multimode fibers, the dispersion in single mode fibers and implications for the systems designs. An overview of the design process for a point-to-point optical link should be given.

**Course Prerequisites:**
The student should be familiar with the basics of communications systems, semiconductor devices and applied electromagnetics.

**Exams and Grades:**
The overall grade consists of homeworks (20%), a presentation (25%) and the final (55%). Five home works will be handed out during the semester. All home works will be graded. Furthermore, each student has to give a presentation on an advanced topic (15-20min. presentation).

**References:**

**Primary Literature**

*Stamatios V. Kartalopoulos, DWDM, Networks, Devices and Technology, IEEE press and Wiley Interscience, 2003.*
The book provides an introduction in communication devices and communication systems, which are based nowadays on Dense-Wavelength-division-multiplexing (DWDM) technology. The book is a very good introduction to Optical Communication on the undergraduate level. **This textbook is the recommended textbook for the course.** Cost: 75 Euro


**Related Literature**

*Eugene Hecht, Optics, Addison Wesly, 4th edition, 2002,*
The book is a very good textbook on optics for an undergraduate optics course.
The book gives an introduction to electromagnetics theory and Maxwell equations. The book is written for 2nd year undergraduate students.

**Advanced Literature**

The book is considered to be the classical book in photonics. Even though the book was published 13 years ago the book covers all-important aspects of photonics. The book is a timeless book and wonderful resources for ideas. The book is on the graduate level. However, the book covers the entire area of Photonics. The book is not addressing the area of optical communication in greater detail. Cost: 115 Euro

The book written by Pollock and Lipson is a very good book on integrated photonics. The book mainly focuses on the mathematical description of optical waveguides and the propagation of waves in optical media. The book is perfect resource for a photonics course on the graduate level. Cost: 136 Euro