OPTOELECTRONICS

1. KEY INDICATORS

CFU/ECTS: 6
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2. OBJECTIVES OF THE COURSE

The course provides a consistent knowledge of phenomena, materials, devices and optoelectronic techniques related to the generation, detection and processing of optical signals for several applications, from telecom, to sensors, to optical instrumentation. The student will acquire the expertise to design and to evaluate performance of most optoelectronic devices.

3. ACQUIRED ABILITIES

The students will acquire capabilities to design and to evaluate performance of devices according to the specifications provided for specific applications, both by lectures and laboratory experiences. Furthermore student will be able to be updated with the state of the art in the field through lectures and seminars of invited international experts.

4. PROGRAM OF THE COURSE

Optical properties of semiconductors: Schrödinger equation, energy- momentum dispersion diagrams, direct and indirect semiconductors. Light absorption, spontaneous and stimulated emission rates in semiconductors. III-V semiconductors, energy bandgaps, technologies. Homojunctions and heterojunctions, single and multi- quantum wells (MQW). Recombination rates and quantum efficiency. Molecular beam epitaxy. Organic semiconductors. Semiconductor LED devices: materials, structures and technologies. Working principle, light current equations and characteristics, modulation characteristics, driving electronics, applications. Coloured and white LEDs. Semiconductor lasers: threshold condition, optical gain and Fabry-Perot cavities. Rate equations. Light-current characteristics. Direct modulation, laser efficiencies. Frequency chirp. Relative intensity noise, phase noise and spectrel width. Single mode lasers, DFB, DBR, VCSEL. MQW lasers, tuneable lasers, diode pumped lasers. Electronic driving circuits and temperature stability. Semiconductor photodetectors. Photoresistors, p-n, p-i-n and Schottky junction photodiodes: materials, structures and technologies. Avalanche photodiodes. Single photon avalanche detectors. MQW photodetectors. Solar cells for terrestrial and space applications. Photocathodes. Vacuum tubes. Charge coupled devices and CMOS for image sensors. Photomultipliers: structures, technology and performance. Integrated optics: slab and rectangular channel dielectric waveguides. Realization techniques. Effective refractive index and guide dispersion. Chromatic dispersion and absorption. Thin and thick grating diffraction. Coupled mode theory and the coherent coupler. Curves and tapers. Radiation and diffusion losses. Mach-Zehnder integrated interferometer. Optical fibers: structures, propagation characteristics, power attenuation and dispersion characteristics. Realization techniques of optical fibers. Optical fiber-waveguide coupling techniques: end-fire, prism, grating coupling. Light propagation in anisotropic materials, index ellipsoid, birefringence, dichroism. Electro-optic Kerr and Pockels effect and acousto-optic effect. Piezolectric effect. Lithium niobate (LNB): crystalline structure, optical properties, electro-optic and acousto- optic coefficients. Realization of LNB titanium in-diffused and annealed proton-exchanged optical waveguides. Integrated optic polarizers, X and Y junctions, polarization beam splitters. Integrated optic phase and amplitude optical modulators, Mach-Zehnder modulators. Definiton and evaluation of half-wave voltage. Overlap integral. Electrical and optical bandwidth of modulators: lumped and traveling-wave electrodes. Integrate optic electro-optic and acousto- optic tunable filters and switches. Fundamentals of photonic crystals (PC): materials and photonic bandgaps. PC waveguides, Purcell's law, nanolaser, photonic nanocircuits, PC fibers. Photonic integrated circuits for optical interconnections. Laboratory experiences on optical fibers, optical CAD tools, lasers power and spectral analysis. Optical couplers and switches.

5. References

G. P. Agrawal, Lightwave Technology: Components and Devices, Wiley Interscience, 2004
A. Yariv, Optical Electronics in Modern Communications, Oxford University Press, 1997
J. Singh, Semiconductor Optoelectronics, McGraw-Hill, 1995
P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall, 1994
H. Nishihara, H. Masamitsu, S. Toshiaki, Optical Integrated Circuits, McGraw-Hill, 1989
Lecture notes and pdf files of the lecture transparencies

6. Course Website

http://elearning2.uniroma1.it/course/view.php?id=91 (registration required)