Laurea Magistrale
Atmospheric Science and Technology (LMAST)

SUBJECT TITLE	OPTOELECTRONIC SENSORS
TEACHER NAME(S)	Antonio d'Alessandro (3 CFU), Rita Asquini (3 CFU)
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Teacher meeting	Thursday 15-17
Teacher office address	Via Eudossiana 18, Rome (S. Peter in chain site)
DISCIPLINE (SSD)	ING-INF/01 (Electronics)
Semester (1-4)	2 (second) Rome
Credits (CFU/ECTS)	6
Lecture hours (h)	60
Prerequisite and learning activity	Basic Electronics and Electromagnetism
Teaching language and method	English & Lectures, exercises and homeworks
Assessment method	Oral examination or written text if requested
SUBJECT WEBSITE	http://antoniodalessandro.site.uniroma1.it; http://ritaasquini.site.uniroma1.it

OBJECTIVES

Main goals are to:

- Provide basic concepts of light-matter interaction in semiconductors
- Describe operation principles of light sources and photodetectors
- Provide design concepts and performance evaluation criteria of sensing devices and microsystems
- Overview of optical instrumentation for remote sensing
- Overview on active and passive sensors for earth observation

OUTCOMES (Dublin descriptors: knowledge, understanding, explain, skill, ability)

After the successful completion of this module, the student should be able to:

- Know operation principles of main optoelectronic components for optical instrumentation and sensing
- Evaluate characteristics and performance of optoelectronic devices
- Choose the appropriate optoelectronic components according to the specific requirement for Earth observation, geomatics, geophysics and environmetrics
- Deal with system applications based on optical techniques

PROGRAM CONTENT

OPTICAL PROPERTIES OF SEMICONDUCTORS AND BASIC ELEMENTS OF QUANTUM MECHANICS

Energy- momentum dispersion diagrams, direct and indirect semiconductors. Light absorption, spontaneous and stimulated emission rates in semiconductors. III-V and II-VI semiconductors, energy bandgaps, technologies. Homojunctions and heterojunctions, single and multi- quantum wells (MQW). Recombination rates and quantum efficiency. Molecular beam epitaxy. Organic semiconductors.

OPTICAL SOURCES

Semiconductor LED devices: materials, structures and technologies. Working principle, light current equations and characteristics, modulation characteristics, driving electronics, applications. Semiconductor lasers: threshold condition, optical gain and Fabry-Perot cavities. Light-current characteristics. Frequency chirp. Relative intensity noise, phase noise and spectrel width. Single mode lasers, DFB, DBR, VCSEL. MQW lasers, tuneable lasers, diode pumped lasers. Quantum cascaded lasers. Electronic driving circuits and temperature stability.

SINGLE ELEMENT AND PIXELLATED PHOTODETECTORS

p-i-n and Schottky junction photodiodes: materials, structures and technologies. Avalanche photodiodes. Single photon avalanche detectors. MQW photodetectors. Charge coupled devices and CMOS for image sensors: operation principles, architectures, noise. Sensor arrays based on CdHgTe and PbSnTe for remote sensing applications.

RADIOMETRY, PHOTOMETRY AND COLORIMETRY CONCEPTS

Radiometric and photometric magnitudes. The human visual system. Colorimetry. Color models and color spaces. Chromaticity diagram. Gamut of an optoelectronic device. Linear transformations for the transition between color spaces. Color temperature. Color measurements.

SOLAR CELLS

Basic concepts on solar radiation. Radiation of the black body. Concept of Air Mass. Operation principles of a solar cell. Effects of temperature on voltage and current. Quantum efficiency. Optical losses. Anti-reflective coatings. Surface texturing. Material thickness. Light entrapment. Lambertian reflectors. Production technologies of silicon solar cells. The market of photovoltaic cells.

PHOTONIC SENSORS AND INSTRUMENTATIONS
LIDAR, LASER altimeters, LASER gyroscopes, telemeters, interferometric sensors, imaging spectrometers, spectroradiometers, polarimeters, visible infrared imaging radiometer suite (VIIRS), earth observation cameras.

REFERENCES AND MATERIAL

Texts and slides provided by the teachers and available on the course web site.

G. P. Agrawal, Lightwave Technology: Components and Devices, Wiley Interscience, 2004.
J. Singh, Semiconductor Optoelectronics, McGraw-Hill, 1995
S. Donati, Electro-optical instrumentation, Prentice Hall, 2004
S. Donati, Photodetectors, Prentice Hall, 2004.
G. C. Righini, A. Tajani, A. Cutolo, An Introduction To Optoelectronic Sensors, World Scientific, 2009.