Corso di Laurea in
SCIENZA E TECNOLOGIA DEI MATERIALI

Triennale – L30

General information		
Academic subject	***LASER MATERIALS PROCESSING***	
Degree course	*MATERIALS SCIENCE AND TECHNOLOGY*	
Academic Year	*3rd*	
European Credit Transfer and Accumulation System (ECTS)		6
Language	*ITALIAN*	
Academic calendar (starting and ending date)	*1ST MARCH 2022 – 8TH JUNE 2022*	
Attendance	*HIGHLY RECOMMENDED, MANDATORY FOR LAB ACTIVITY*	

Professor/ Lecturer	
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Virtual headquarters	*Codice Teams: zx8dhz1*
Tutoring (time and day)	Tue-Thu 9.30-11.30

Syllabus	
Learning Objectives	*- basic knowledge of the structure of matter, physics and chemistry of condensed states, with operational and laboratory skills;* *- knowledge and skills useful for designing the properties of materials, starting from the atomic and molecular structures* *- being able to intervene in production processes and to follow the scientific, technological and industrial evolution of the sector;*
Course prerequisites	*Electromagnetism and waves, linear optics, differential equations, bases of crystallography and atomic and molecular spectroscopy, structure of matter*
Contents	*Light-atom interaction (absorption, spontaneous emission, stimulated emission), optical saturation, population inversion. Fundamental elements of a laser: active medium, pump systems, optical cavities and laser resonators, optical gain, losses and laser threshold. Longitudinal and transverse modes of a laser. Properties of lasers: monochromaticity, spatial and temporal coherence, divergence, brightness. Semiclassical treatment of the laser with two levels. Balance equations of lasers with 3 and 4 levels. Optical cavities. Gas, solid state, fiber and semiconductor lasers. Generation and control of short and ultra-short pulses: Q-switching and mode-locking. Generation and control of the emission frequency. Laser safety. Overview of laser applications in the field of materials processing: cutting, welding, drilling, milling, marking, surface treatments, additive manufacturing.* *Laboratory experiences: Measurement of the M2 factor of a laser beam; Measurement of the laser ablation threshold of a metal*
Books and bibliography	O. Svelto, Principles of Lasers, 5th Edition (capitoli 3,8,9,10). M. Csele, Fundamentals of light sources and lasers, Wiley 2004 (capitoli 4,5,6,7)

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	Elijah Kannatey-Asibu, Jr., Principles of lasers materials processing, Wiley 2009 (capitoli 14,15,16,17,23)
Additional materials	

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
150	*32*	*30*	*88*
ECTS			
6	*4*	*2*	

Teaching strategy	*Lectures, Laboratory experiences.* *The teaching is preferably delivered in frontal teaching but if necessary it can also be delivered remotely.*
Expected learning outcomes	
Knowledge and understanding on:	○ the basic aspects of the operation of a LASER source connected to the physics and spectroscopy of atoms and molecules, ○ the properties and characteristics of the LASER sources, ○ the main applications of LASER sources with particular reference to the LASER materials processing, ○ the risks associated with the use of LASER sources
Applying knowledge and understanding on:	○ ability to identify the most appropriate laser source according to the process and material to be processed by comparing different types of sources and processing systems, ○ ability to measure the M2 coefficient of a laser beam, ○ ability to estimate the laser ablation threshold of a material, ○ knowledge of the safety regulations related to the work areas in which the LASERs are used
Soft skills	• *Making informed judgments and choices* ○ evaluate the most appropriate communication strategy (report, demonstration, seminar), the reliability of the experimental data, the laser source and the most appropriate system (robot, gas supply, optics, etc.) depending on the application / process and the material to be processed and the relative safety measures to be adopted • *Communicating* knowledge and understanding ○ use of scientific language appropriate to the context (technical or informative), use of analogies with situations and phenomena of common perception in related areas • *Capacities to continue learning* ○ from the exchange of material with other groups, from online bibliographic sources, from the analysis of errors in laboratory practice

Assessment and feedback	
Methods of assessment	*Written reports on laboratory experiences (40%). Oral examination for the theoretical part where the knowledge of the course contents, the ability to elaborate the concepts learned and the ability to choose the type of laser with the*

	most appropriate characteristics based on its specific application will be evaluated (60%).
Evaluation criteria	• *Knowledge and understanding* ○ a qualitative but precise knowledge of the operating principles of a LASER, its properties and characteristics and its main applications and the main risks associated with the use of LASERs is sufficient; formal knowledge of the balance equations of 3 and 4 level lasers is positively evaluated • *Applying knowledge and understanding* ○ it is sufficient to identify the type of laser useful for each specific application, to know how to build and align an optical chain, to know how to identify the main safety measures to be taken to prevent the risks associated with the use of LASERs; the ability to apply knowledge to physical situations not covered in detail during the course is positively evaluated • *Autonomy of judgment* ○ it is necessary to justify the use of the appropriate terminology and models; the argumentative capacity of the project choices is positively evaluated; • *Communicating knowledge and understanding* ○ scientific terminology must be used correctly; the use of multimedia or demonstration communication methods is positively evaluated*Communication skills* • *Capacities to continue learning* ○ it is necessary to demonstrate individual contribution to group work; the ability to draw autonomously from different sources and to apply autonomously acquired knowledge to problem solving is positively evaluated
Criteria for assessment and attribution of the final mark	*The final grade is awarded out of thirty. The exam is passed when the grade is greater than or equal to 18*
Additional information	