COURSE OUTLINE

(1) GENERAL INFORMATION

SCHOOL	SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
DEPARTMENT	SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
LEVEL OF STUDIES	POSTGRADUATE		
MSc PROGRAM	MICROSYSTEMS AND NANODEVICES		
COURSE CODE	**9968**	**SEMESTER**	**2**
COURSE TITLE	SPECIAL TOPICS IN NANOTECHNOLOGY		

INDEPENDENT TEACHING ACTIVITIES *In cases where credits are awarded to discrete parts of the course (e.g., Lectures, Laboratory Exercises, etc.), specify them. If credits are awarded as a whole, specify weekly teaching hours and total credits.*	**WEEKLY TEACHING HOURS**	**ECTS**
Lectures – Exercises	2.5	6
Laboratory	0.5	
Assignments		
(Additional rows may be added if necessary. Detailed descriptions of teaching organization and methods are provided in section (d).)		

COURSE TYPE *general background, specialized background, specialization, skill development*	GENERAL BACKGROUND
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Chemistry, Physics, Mathematics
LANGUAGE OF INSTRUCTION and EXAMINATION:	GREEK
COURSE AVAILABLE TO ERASMUS STUDENTS	YES (offered in English as a reading course).
COURSE WEBSITE (URL)	https://helios.ntua.gr/course/view.php?id=3021

(2) LEARNING OUTCOMES

Learning Outcomes

This section describes the learning outcomes of the course, specifying the knowledge, skills, and competencies at the appropriate level that students will acquire upon successful completion of the course.

Refer to Appendix A:

- *Description of the Level of Learning Outcomes for each cycle of studies according to the European Higher Education Area Qualifications Framework*
- *Descriptive Indicators for Levels 6, 7, & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B.*
- *Concise Guide to Writing Learning Outcomes*

Knowledge:

The course provides knowledge on:

Methods for stabilizing and dispersing nanoparticles. New dispersants suitable for nanoparticles. Pseudogranulation through spray freeze drying. Mechanochemical activation. Homogeneous and heterogeneous nucleation. Hybrid nanoparticle synthesis in the presence of polymer matrices. Biomimetic synthesis techniques. Hydrochemical techniques for synthesizing nanometallic materials. Shaping and advanced sintering techniques for nanoparticles. Production of thin films through physical and chemical deposition techniques. Thin film deposition using pulsed laser. Production of nanostructured coatings using wet chemical methods or liquid plasma spraying.

Properties, applications, and synthesis methods for precious metal nanoparticles. Properties, mechanisms of action, and environmental applications of iron nanoparticles.

Skills:

Upon successful completion of the course, students will be able to:

- Understand the mechanisms of growth for nanomaterials and nanostructures.
- Comprehend and address nanoparticle dispersion challenges.
- Apply various techniques to develop desired nanostructures.
- Combine appropriate techniques to handle nanoparticles and achieve three-dimensional structures.
- Gain in-depth knowledge of thin film development techniques.
- Understand the primary mechanisms of action for precious metals in medical (diagnostic and therapeutic) and catalytic applications.
- Understand the multiple mechanisms of action of metallic nano-iron in environmental applications.
- Apply environmentally friendly techniques for nanoparticle synthesis.
- Study the kinetics of simple chemical reactions through appropriate laboratory testing.

General Competencies

Considering the general competencies that graduates are expected to acquire (as stated in the Diploma Supplement), which competencies does this course aim to develop?

Data search, analysis, and synthesis, utilizing necessary technologies *Adaptability to new situations* *Decision-making* *Independent work (primarily through assignments completed at home)* *Teamwork* *Working in an international environment* *Working in an interdisciplinary environment*	*Generation of new research ideas* *Project design and management* *Respect for diversity and multiculturalism* *Respect for the natural environment* *Exhibiting social, professional, and ethical responsibility and sensitivity to gender issues* *Critical and self-critical thinking* *Promotion of free, creative, and inductive thinking*

Competencies:

Upon successful completion of the course, students will develop the ability to:

- Work independently.
- Combine and develop laboratory techniques to achieve desired nanostructures.
- Critically evaluate literature data.
- Design and conduct appropriate laboratory tests to determine critical physicochemical parameters.

(3) COURSE CONTENT

Weekly Course Schedule:

- **Week 1:** Introduction. Nanoparticle aggregation – issues in producing dense nanostructures via sintering techniques. Surface chemistry of solids: chemical potential, surface charge density. Stabilization and dispersion methods for nanoparticles. Electrostatic stabilization. DLVO theory. Steric stabilization.
- **Week 2:** New dispersants suitable for nanoparticles. Pseudogranulation via spray freeze drying. Mechanochemical activation.
- **Week 3: Laboratory Exercise:** Drying of nanopowders via lyophilization.

- **Week 4:** Homogeneous and heterogeneous nucleation. Hybrid synthesis of nanoparticles in polymer matrices. Biomimetic synthesis.
- **Week 5: Laboratory Exercise:** Preparation of nanodispersed CeO_2 suspension.
- **Week 6:** Shaping and advanced sintering techniques for nanoparticles.
- **Week 7: Laboratory Exercise:** Development of SiO_2@CeO_2 core-shell particles.
- **Week 8: Laboratory Exercise:** Hybrid synthesis of hydroxyapatite nanopowders.
- **Week 9:** Production of thin films through physical and chemical deposition techniques. Thin film deposition using pulsed laser. Production of nanostructured coatings using wet chemical methods or liquid plasma spraying.
- **Week 10:** Metallic nanoparticles of precious metals.
- **Week 11:** Iron nanoparticles and their environmental applications.
- **Week 12: Laboratory Exercise:** Synthesis of elemental nano-iron using green tea extract and application for removing hexavalent chromium from polluted water.
- **Week 13: Laboratory Exercise:** Dispersion of elemental nano-iron in cationic resin.

(4) TEACHING AND LEARNING METHODS - ASSESSMENT

TEACHING METHOD *In person, Distance Learning etc.*	In person
USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) *Use of Information and Communication Technologies (ICT) in Lecturing, Laboratory Training, Communication with Students*	Course Notes, Assignments for Home Study **(**Assignments are provided by the lecturer, and students are required to submit completed work)
ORGANIZATION OF TEACHING *A detailed description of the teaching methods and approaches used in the course, which may include:* *Lectures, Seminars, Laboratory Exercises, Fieldwork, Study and Analysis of Bibliography, Tutorials, Internships, Clinical Exercises, Art Workshops, Interactive Teaching, Educational Visits, Project Development, Report Writing/Assignments, Artistic Creation.* *The student's study hours for each learning activity, as well as hours of independent study, are outlined in accordance with ECTS principles.*	see table below

Activity	***Semester Workload***
Lectures	7x3=21 hours
Study	7x5=35 hours
Home Assignments/Exercises	6x6=36 hours
Laboratory	6x3=18 hours
Completion/Presentation of Project	36 hours
Educational Visits	
Examinations	
Total Course Load	146 hours

STUDENT ASSESSMENT *Description of the Assessment Process* *Language of Assessment, Assessment Methods, Formative / Summative Assessment Methods, Multiple-choice tests, Short-answer questions, Essay-style questions, Problem-solving exercises, Written assignments, Reports, Oral examinations, Public presentations, Laboratory work, Clinical patient examinations, Artistic interpretations, Other methods, as appropriate* *The assessment criteria are clearly defined and provided to students, ensuring transparency in the evaluation process. These criteria are accessible through the course's online platform where students can review them at any time.*	**Language of Assessment:** Greek (for Erasmus students: English) Completion/Presentation of Project**:** 70% of the final grade Laboratory Exercise Reports: 30% of the final grade Explicit mention of these assessment criteria will be available on the Helios platform.

(5) RECOMMENDED BIBLIOGRAPHY

Review Bibliography

- *Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Imperial College Press, London, 2005.*
- *Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties, and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.*
- *C.N.R. Rao, A. Müller, The Chemistry of Nanomaterials: Synthesis, Properties, and Applications, Vol. 2, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2006.*
- *R. Kelsall, I. Hamley, & M. Geoghegan, Nanoscale Science and Technology, J. Wiley & Sons Ltd, West Sussex, England, 2005.*
- *M. Adachi & D. J. Lockwood, Self-Organized Nanoscale Materials, Springer, NY, 2006.*
- *L.B. Freund & S. Suresh, Thin Film Materials: Stress, Defect Formation, and Surface Evolution, Cambridge University Press, Cambridge, 2006.*
- *R. Eason, Pulsed Laser Deposition of Thin Films: Applications-Led Growth of Functional Materials, J. Wiley & Sons Inc., Hoboken, New Jersey, USA, 2007.*