ETE805 - Chemistry of materials – nanoporous and layered materials

COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	ETE805	**SEMESTER**	6º
COURSE TITLE	Chemistry of materials – nanoporous and layered materials		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
LECTURES	3	3
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Hellenic
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes in english
COURSE WEBSITE (URL)	http://www.materials.uoi.gr/ccl/LNM-Teach.html

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The purpose of the course is to understand the techniques used for the synthesis of traditional and advanced materials as well as to give a detailed description of the structure, properties and applications of the most important layered (2D) and nanoporous materials. Thus, the first part describes the main methods of preparation of materials such as solid state techniques, liquid solutions, hydrothermal, deposition, etc. The second part deals in detail with two-dimensional materials such as clays, layered double hydroxides, germanane, etc., nanoporous materials such as zeolites and M41S materials, as well as carbon-based nanostructured materials such as fullerenes, carbon nanotubes, graphene, graphene oxide, carbon nanodiscs and nanodots, etc.

Every year the course is updated gradually in order to keep up-to-date on research and development issues. The materials (nanostructures) as well as the methods of fabrication of materials discussed are among the newest and most innovative, therefore the material is constantly updated. Some examples are: the "graphene" (Nobel Prize in Physics 2010) introduced in the last decade, germanane and Mxenes introduced the last four academic years.

The course is placed in the 6th semester. Students have been taught several chemistry and

materials science courses and are thus prepared, in terms of the necessary theoretical background, to be able to attend. There is a direct link with several courses mainly laboratories courses such as Materials Lab II which includes, among others, the synthesis and characterization of new innovative nanomaterials as well as 5th year courses such as Special Topics of Ceramics and Bioceramics.

Knowledges: Familiarization and education of the student in modern methods of materials preparation. Identification and understanding of the structure, properties and structural and physicochemical characteristics of layered (two-dimensional) materials and nanoporous materials. Understanding the role of each advanced material for the development of innovative functional materials, devices and systems targeting specific technological applications (energy, environment, catalysis, chemical industry, etc.).

Skills: Combining knowledge of materials chemistry (in micro and nano dimensions) and understanding the structure, properties and uses of layered and nanoporous materials the student can select the appropriate materials and design the appropriate devices aiming at specific technological applications. Thus, the student acquires the opportunity to develop the necessary skill and innovation to solve complex problems in the development of operating devices or systems that target specialized areas such as energy, environment or health.

Abilities: Combining knowledge of materials chemistry in micro and nano-dimensions and understanding the structure and properties of new innovative low-dimensional materials belonging to the category of two-dimensional and nanoporous materials, the student can understand both the characteristics of other nanostructures and the basic operating principles and other functional materials, devices and systems that have not been taught. As a consequence, students can compare and evaluate their differences, make a good use of the new literature and thus they can take decisions to modify, redesign and re-optimize the materials used and their configurations for specific technological applications.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search, analyze and synthesize data and information, using the necessary technologies
- Adaptation to new situations
- Decision making
- Independent work
- Generation of new research ideas
- Exercising criticism and self-criticism
- Promoting free, creative and inductive thinking

(3) SYLLABUS

1st Part – Chemistry of Materials

A. Synthetic methods for materials preparation

1. Introduction
2. Ceramic methods (solid state reactions)
3. Microwave synthesis
4. Sol-gel method
5. Template method («chemical engineering»)
6. Precursor method
7. Hydrothermal methods
8. Chemical vapour deposition (CVD)

9. Vapour phase epitaxial growth (VPE)
10. Molecular beam epitaxy (MBE)
11. Chemical vapour transport (CVT)
12. Intercalation reactions
13. Langmuir-Blodgett method
14. Method selection rules
14. Exercises – Problems

2nd Part – Nanoporous and Layered Materials

B. Nanoporous and layered materials

1. Introduction – porous materials classification
2. Zeolites
3. Mesoporous materials
4. Layered clays – Pillared clays – clay/polymer nanocomposites
5. Carbon nanostructured materials: fullerenes, carbon nanotubes, graphene, graphen oxide, carbon nanodiscs, carbon nanodots, mesoporous carbons, carbon cuboids, hierarchical porous carbons, etc.
6. Other 2D materials: germanane, silicene, transition metal dichalcogenides (TMDs), MoS_2, MXenes, layered double hydroxides (LDH), etc

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	During communication with students
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Written final examination in normal examination periods *Assessment language*: Greek (or English for ERASMUS students) *Procedure*: Written examinations with development and short answer questions, and problem solving.

Activity	***Semester workload***
Lectures	39
Study and analysis of bibliography	20
Essay writing	16
Course total	75

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Chemistry of Materials- Nanoporous & Layered Materials (D. Gournis), Ioannina, 2006,

p.p. 100

- Related academic journals:

- Review articles, as well as, regular articles by international publishers ACS, RSC, Wiley, Springer, etc., doctoral theses, postgraduate dissertations etc.