

Bonding, Crystallography and Crystal Defects

1. GENERAL			
SCHOOL	Faculty of Sciences in collaboration with Faculty of Engineering, Aristotle University of Thessaloniki		
DEPARTMENT	Materials Science and Engineering		
LEVEL OF STUDIES	ISCED level 7 (5-year Integrated Master's programme) ISCED level 6 (4-year BSc programme)		
COURSE CODE	MSEN 205	SEMESTER	2 nd Semester
COURSE TITLE	Bonding, Crystallography and Crystal Defects		
TEACHING ACTIVITIES	TEACHING HOURS PER WEEK	ECTS CREDITS	
Lectures, tutorials/problem sessions, laboratory/computer exercises (where applicable), case studies and guided self-study.	4	6	
COURSE TYPE	<p>Students will develop:</p> <ul style="list-style-type: none"> A foundational understanding of the fundamental aspects of the structure of matter needed for later courses relevant to the properties and processing of materials`. Familiarity with the basic instrumentation (x-ray diffractometers) used for the study of microstructure of materials Practicing the scientific method, evidence-based reasoning, and quantitative analysis, in realistic conditions. <p>Students will be able to:</p> <ul style="list-style-type: none"> Understand and apply the structure of matter (how atoms, molecules and clusters align in space, the interactions among them, the formation of crystals, and the basic crystallographic systems, the origin and manifestation of defects in crystalline materials). Demonstrate an understanding of experimental measurement of x-ray diffraction for the study of the structure of matter. 		
PREREQUISITES	No prerequisites		
TEACHING AND EXAMINATION METHODS	English		
COURSE OFFERED TO ERASMUS STUDENTS	Yes.		
COURSE URL	https://elearning.auth.gr/course/view.php?id=xxxxx		

2. LEARNING OUTCOMES	
Learning Outcomes	<p>Upon successful completion of this course, students will be able to:</p> <ul style="list-style-type: none"> Describe the fundamental types of chemical bonding in solids (ionic, covalent, metallic, van der Waals, hydrogen bonding). Explain how bonding determines crystal stability, structure, and macroscopic properties. Identify, classify, and describe crystal structures using symmetry operations, crystal systems, Bravais lattices, point groups, and space groups.

	<ul style="list-style-type: none"> • Apply Miller indices, reciprocal lattice concepts, and Bragg's law to interpret diffraction patterns. • Understand the physical principles of X-ray, electron, and neutron diffraction. • Interpret real diffraction diagrams and extract structural parameters (unit cell, symmetry, interplanar distances). • Recognize, describe, and model crystal defects (point, line, and planar defects). • Evaluate the influence of defects on diffusion, conductivity, mechanical behavior, and materials performance. <p>Use crystallographic software tools to visualize and analyze structures and defects</p>
General Skills	<p>Students will also acquire:</p> <ul style="list-style-type: none"> • Search, analysis, and synthesis of data with ICT (Information and Communication Technologies) • Decision-making • Teamwork and interdisciplinary collaboration • Problem-solving and analytical thinking • Application of theoretical knowledge in laboratory settings • Respect for the natural environment

3. COURSE CONTENT

Fundamental crystallographic concepts; Structure of crystals: lattice, basis, translational symmetry; Connection between crystallographic theory and X-ray techniques; Introduction to X-ray diffraction (XRD); Bragg's law and structure factor; Interaction of X-rays with matter; **Experimental Verification of Bragg's Law**; Structure–property relationships; **Crystal Defects: Point, Line and Planar defects**; Impact of defects on the properties of materials.

4. LEARNING & TEACHING METHODS - EVALUATION

Teaching method	Face-to-face.						
Use of ICT	<p>ICT plays a significant role in enhancing teaching, learning, experimentation, visualization, and assessment in this course as follows:</p> <p>Computational Tools for Problem Solving: Spreadsheet calculations (Excel, Google Sheets), Coding solutions in Python, MATLAB, or Mathematica</p> <p>Online Learning Platforms: Learning management systems (LMS) like Moodle, Online lectures, video tutorials, and animations,</p> <p>Communication and Collaboration: Online discussion forums, Collaborative documents, Sharing of data and reports</p> <p>Presentation and Reporting Tools: Lab reports (word processors), Data plots and charts (graphing tools), Presentations (PowerPoint, Google Slides).</p>						
Teaching organization	<p>The supervised and unsupervised workload per activity is indicated below (total workload complies with ECTS standards).</p> <table border="1"> <thead> <tr> <th>Activity</th> <th>Workload/semester (hours)</th> </tr> </thead> <tbody> <tr> <td>Lectures</td> <td>26</td> </tr> <tr> <td>Laboratory / Experimental Work</td> <td>24</td> </tr> </tbody> </table>	Activity	Workload/semester (hours)	Lectures	26	Laboratory / Experimental Work	24
Activity	Workload/semester (hours)						
Lectures	26						
Laboratory / Experimental Work	24						

	Written assignment / exercises	50
	Total	150
Student evaluation	<p>Assessment Language: English</p> <p>Methods of Assessment:</p> <ul style="list-style-type: none"> • Final written exam (multiple choice, short answers, problem solving) • Problem-solving exercises • Laboratory or computational reports • Homework assignments • Optional presentations • Student Information: <p>Detailed exam criteria and guidelines are posted on e-class</p> <ul style="list-style-type: none"> • Sample exercises and past material provided online 	

5. SUGGESTED BIBLIOGRAPHY

Course Bibliography

- Callister, *Materials Science and Engineering*
- Shackelford, *Introduction to Materials Science for Engineers*
- Askeland, *The Science and Engineering of Materials*

Additional bibliography for study

- De Graef & McHenry, *Structure of Materials*
- Cullity, *Elements of X-Ray Diffraction*
- Kittel, *Introduction to Solid State Physics*