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# Syllabus of “Materials Design and Processing Using Artificial Intelligence”

## Course Information

Course Code	MSE 5617	Credit Hours	32	Credits	2
Course Name	Materials design and processing using artificial intelligence				
Course Type	cross-curricular				
Audience	Internationalization Pilot Course for Undergraduate Students majoring in Materials				
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science (1), Principles of Materials Processing (2), Materials Properties (1 - Mechanical Properties), Principles of Materials Processing				
Instructor	Da Shu	Course Webpage			
Description	<p>Requirements are urgent to pursue high performance materials, complexity and lightweight components, high efficiency and low cost of production through alloy composition design, process optimization, and accurate control of preparation and processing. In today's information and intelligent era, materials design and processing using artificial intelligence (AI) has become an important development direction of materials science, which is of great significance to drive the transformation and upgrading of traditional industries, accelerate the development of new materials and the development of complex structural components. This course introduces AI technology and its application in materials science and engineering. The course mainly includes three aspects: 1) AI algorithms (machine learning, deep learning, data mining, etc.); 2) data-driven materials design and microstructural analysis and property prediction; 3) integrated computing and data driven materials processing optimization. Through the study of this course, it will help students to establish the interdisciplinary knowledge system of materials and computer science, and cultivate the interdisciplinary talents with innovative consciousness in the background of new engineering.</p>				
Course objectives and contents					
Course Objects	<p>(1) Be able to understand the current application status and development trends of materials science, computer science, data science, and artificial intelligence in the field of materials design and processing;</p> <p>(2) Be able to understand and apply computer imaging related knowledge to carry out intelligent identification and analysis of typical material microstructures;</p> <p>(3) Be able to understand and apply machine learning and high-throughput experimental/simulation methods to predict material properties;</p> <p>(4) Be able to understand and apply methods, such as integrated computational materials engineering and machine learning, to optimize material processing parameters and identify key property parameters.</p> <p>(5) Cultivate patriotism, as well as personal character of diligence, perseverance, hard work, and bravery.</p>				

	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
Class Schedule & Requirements & Course Objectives	Overview	The concept, history, and development status of AI, as well as the current status and development trends of material intelligent design and processing	2	Classroom teaching	No	Objective (1) & Objective (5)
	Fundamentals of AI Algorithms	Optimization algorithms, neural networks, linear classification support vector machines	8	Classroom teaching	Comparing the differences between different ML algorithms	Objective (1) & Objective (3)
	Experiment-1	Building an ANN with Mathematica and perform prediction with it	2	Experiment	Experimental report	Objective (1) & Objective (2)
	Data driven materials design	Material database, intelligent characterization of organizational structure, intelligent identification of parameters, and intelligent prediction of performance	8	Classroom teaching	Summarize the application of ML algorithms in materials design	Objective (2) & Objective (3)
	Experiment-2	Intelligent Identification of Martensitic Phase in Dual Phase Steel	2	Experiment	Experimental report	Objective (1) & Objective (2)
	Intelligent design of material processing technologies	Data-driven casting process design, intelligent design of hot stamping molds, intelligent optimization of 3D printing processes, and digital twinning	8	Classroom teaching	Summarize how AI solves materials processing problems	Objective (1) & Objective (4) & Objective (5)
	Final report	Literature research and presentation on the latest application progress of AI in materials design and processing	2	Interactive discussion	Poster exhibition & Oral presentation	Objective (1) & Objective (2) & Objective (3) & Objective (4)
	Grading	1. Homework and attendance: 20%; 2. Experiments: 30%;				

	3. Final report: 50%.
Textbooks & Other Materials	<p>S. R. Kalidindi, "Hierarchical Materials Informatics", (Butterworth Heinemann 2015), ISBN 9780124103948.</p> <p>Jay Lee, Industrial AI: Applications with Sustainable Performance, Springer; 2020.</p> <p>李杰, 工业人工智能, 上海交通大学出版社, 2019.</p> <p>涌井良幸, 涌井贞美著, 杨瑞龙译, 深度学习的数学, 人民邮电出版社, 2019.</p>
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Notes	

## Syllabus of “Materials Chemistry” (2024)

### Course Information

Course Code	MSE2602-1	Credit Hours	32	Credits	2
Course Name	Materials Chemistry				
Course Type	Required course				
Audience	Sophomore				
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite	College Chemistry; College Physics; Thermodynamics Thermodynamics of materials.				
Instructors	Prof. Huanan Duan, Prof. Chuanliang Feng	Course Webpage	<a href="https://oc.sjtu.edu.cn/courses/63727">https://oc.sjtu.edu.cn/courses/63727</a>		
Description	<p>Materials chemistry is the study of the synthesis, structure, properties, and application of solid materials. Our technology-driven world is fuelled by advances in materials chemistry with examples of application in areas such as microelectronics, polymers, and energy technology. This course introduces the materials chemistry of several major categories of materials (metals, ceramics and glasses, semiconductors, polymers, nanomaterials) with the emphasis of materials synthesis. The topics span from traditional extractive metallurgy to more recent development of nanomaterials and biomaterials.</p> <p>Through the study of this course, students can master the basic knowledge and theory in the field of materials science and chemical preparation in the material industry, understand the industrial status of related fields, research frontiers, and the concepts of environmental protection and sustainable development that may be involved, and learn to analyze and solve problems by applying the basic knowledge and literature study. This course also lays a good foundation of knowledge in materials chemistry and thinking methods for the undergraduate study of materials discipline.</p> <p>The main contents of this course include the introduction of material chemistry, the theoretical basis of bonding theory and crystal field theory, basic metallurgy methods, the electrochemical methods, preparation methods for inorganic materials (including nanoparticles, thin films, ceramics etc.), synthesis and preparation of polymer materials; the chemistry of organic/inorganic hybrid materials.</p>				
Course objectives and contents					

Course Objects	<p>(1) Master the fundamental knowledge of materials chemistry, and understand the development history, current development status and future development trends of materials chemistry. Gain a deep understanding of the important role that chemistry and chemical processes play in the development and use of materials. (Supports graduation requirements 1.1, 1.2)</p> <p>(2) Use appropriate theories to describe and analyze practical problems in materials design, preparation, and processing to find solutions. (Supports graduation requirement 2.1)</p> <p>(3) Cultivate students' information retrieval ability and understand the specific application examples of various synthesis methods, structures, and properties involved in this course in materials research and development. (Supports graduation requirements 4.1, 10.2)</p> <p>(4) Understand the social, environmental and other relevant considerations reflected in the design of specific systems, technologies or processes in materials engineering. (Supports graduation requirement 7.2)</p>			
Correspondence between graduation requirement indicator points and course objectives	Contents	Objectives	Graduation Requirements Indicator Points	Teaching methods
	Engineering knowledge and international frontiers	Master professional basic theoretical knowledge, professional knowledge, and experimental skills	1	Lectures, assignments, discussions
		Understand the research frontiers and development trends of this major	1	
	Problem analysis	Ability to use relevant scientific principles to identify and judge the key links of complex engineering problems and solve them	2	Lectures, experiments, assignments, exams
	Research	Ability to investigate and analyze solutions to complex engineering problems based on scientific principles and through literature research or related methods	3	Lectures, assignments, discussions
	Engineering and society, environment, sustainable development	Ability to evaluate the sustainability of materials science and engineering practices from the perspective of environmental protection and sustainable development, and evaluate the impact of products on the	4	Lectures, assignments, discussions
	Life-long learning	Master the ability of lifelong learning in foreign languages, computers, literature retrieval, etc., and be able to grasp the professional frontiers from academic reports.	3	Lectures, assignments, reports, discussions

Class Schedule & Requirements	Chapter	Hours	Method	Assignment	Learning objectives	Quiz	
	Chapter 1 Introduction to Mater. Chemistry	2	Lecture	Homework (HW)	<ul style="list-style-type: none"> <li>To explain why different materials are different</li> <li>To appraise the trend of materials development</li> <li>To relate the Mater. Chem. to Mater. Sci. &amp; Eng. and the</li> </ul>		
	Chapter 1 Polymers (12)						
	Polymer overview	2	Lecture	HW	<ul style="list-style-type: none"> <li>Basic concepts of polymers</li> <li>Classification and naming of polymer compounds</li> <li>Classification of polymerization reactions</li> <li>Average molecular weight of polymer and its distribution</li> <li>Polymer physical state and</li> </ul>		
	Free radical polymerization	2	Lecture	HW	<ul style="list-style-type: none"> <li>Free radical polymerization mechanism</li> <li>Chain-initiated reaction</li> <li>Free radical polymerization kinetics</li> <li>Average polymerization degree of polymer</li> <li>Factors affecting free radical polymerization</li> <li><u>Inhibition and retardation</u></li> </ul>		
	Ionic polymerization	2	Lecture	HW	<ul style="list-style-type: none"> <li>Cationic polymerization</li> <li>Anionic polymerization</li> <li>The difference between ionic polymerization and free radical polymerization</li> <li>Coordination polymerization</li> </ul>		
	Stepwise polymerization	2	Lecture	HW	<ul style="list-style-type: none"> <li>Gradual addition polymerization</li> <li>The molecular weight distribution</li> <li>Stepwise polymerization method</li> </ul>		

Organic/ inorganic hybrid materials chemistry	2	Lecture	HW	<ul style="list-style-type: none"> <li>• Concept of organic / inorganic hybrid materials</li> <li>• Self-assembled organic / inorganic hybrid nanomaterials</li> <li>• Hybridization of organic components on inorganic surfaces</li> </ul> <p>Bionic organic / inorganic hybrid materials</p>	
	2				Quiz 1
Chapter 2 Metals (6)					
Metals	2	Lecture	HW	<ul style="list-style-type: none"> <li>• To understand molecular orbital theory</li> <li>• To sketch the concept of electronic band structure</li> <li>• To use the electronic band structure to explain some</li> </ul>	
Extractive Metallurgy	2	Lecture	HW	<ul style="list-style-type: none"> <li>• To weight pyrometallurgy and hydrometallurgy by comparing two cases: extraction of Fe and Cu</li> <li>• To list general steps of hydrometallurgy</li> <li>• To explain pyrometallurgy, hydrometallurgy, and leaching.</li> </ul>	
Electrometallurgy	2	Lecture		<ul style="list-style-type: none"> <li>• to use the standard reduction potential table to explain phenomena</li> <li>• to select appropriate electrolyte for electrolysis</li> <li>• to assess different corrosion</li> </ul>	Quiz
Chapter 3 Ceramics (9)					
Overview and crystal field theory	2	Lecture	HW	<ul style="list-style-type: none"> <li>• To sketch crystal field splitting diagrams for oct. and tetra. complexes</li> <li>• To calculate the crystal field stabilization energy</li> <li>• To apply the crystal field theory to predict properties of coordination complexes</li> </ul>	

Solid state reaction (SSR)	2	Lecture	HW	<ul style="list-style-type: none"> <li>To describe general steps involved in solid-state reactions</li> <li>To explain diffusion and its mechanism</li> <li>To describe the driving forces for sintering</li> </ul>	
Experiment	2	Experiment		<ul style="list-style-type: none"> <li>To have hands-on experience on sintering</li> <li>To do virtual experiment to appreciate SSR</li> </ul>	
Solution chemistry	1	Lecture	HW	<ul style="list-style-type: none"> <li>To analyze the surface charge of a colloidal particle</li> <li>To apply the EDL to analyze the stability of colloids</li> </ul>	
Solution-based synthesis	2	Lecture		<ul style="list-style-type: none"> <li>To explain alkoxides, hydrolysis, and condensation</li> <li>To analyze a sol-gel process</li> <li>To explain the water property under hydrothermal conditions</li> <li>To design an autoclave based on the solubility-temperature plots</li> </ul>	Quiz
Chapter 4 Semiconductors (5)					
Semiconductors and Si production	1	Lecture	HW	<ul style="list-style-type: none"> <li>To apply the band structure model to explain properties of semiconductor and working mechanisms of devices</li> <li>To sketch the electronic band structure of doped semi and p-n junctions</li> <li>To describe the CZ method and the float-zone method</li> </ul>	
Lithography	2	Lecture	HW	<ul style="list-style-type: none"> <li>To describe photolithography:</li> <li>Environment: clean room</li> <li>Components: light source and photoresist</li> <li>Step-by-step process of photolithography</li> </ul>	
Thin film depositions	2	Lecture		<ul style="list-style-type: none"> <li>Be able to describe the basic mechanisms of the additive processes:</li> <li>Physical Vapor Deposition (evaporation, sputtering)</li> <li>Chemical Vapor Deposition</li> </ul>	Quiz

	Summary
Assessment	Homework, virtual experiment and class participation 35% + Mind maps 15% + Mid-term 15% + Final exam 35%
Textbooks	<p>There is no required textbook. Below are a few reference books:</p> <p>(1) Introduction to Materials Chemistry, Harry R. Allcock, Wiley 2008.</p> <p>(2) Solid State Chemistry, Anthony R. West, Wiley 2013.</p> <p>(3) Ceramic Processing and Sintering by Rahaman, CRC Press, 2003.</p> <p>(4) Materials Chemistry by B. Fahlman, Springer, 2011 (Available as a free ebook through the SJTU library website).</p> <p>(5) Chemistry – the Central Science by Theodore L. Brown, H. Eugene LeMay, Jr., Bruce E. Bursten, Catherine J. Murphy, and Patrick Woodward, Pearson Education, Inc., 2009</p>
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## Syllabus of “Mechanical Behavior of Materials”

### Course Information

Course Code	MSE 3608	Credit Hours	48	Credits	3
Course Name	Mechanical Behavior of Materials				
Course Type	cross-curricular				
Audience	Internationalization Pilot Course for Undergraduate Students majoring in Materials				
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science (2)				
Instructor	Lingti Kong	Course Webpage			

**Description**

The mechanical properties of materials are the responses of materials to external loading, which might be coupled with high temperature, a corrosive environment, or other fields. This course covers both the macroscopic and the microscopic aspects of elastic deformation, plastic deformation, fracture, fatigue, creep, stress corrosion cracking, and wear of metals, ceramics, polymers, and composite materials. The roles of composition, bonding, and structure (crystalline, defects, and microstructure) in controlling and influencing the properties as well as the methods to measure/evaluate/interpret the various properties are discussed.

### Course objectives and contents

- Course Objects**
- (1) Master systematic knowledge of the mechanical behavior and properties of materials, and understand the forefront and development trends in the study of material mechanics behavior.
  - (2) Acquire skills and methods for material mechanics performance testing experiments, understand the latest testing equipment and methods, possess the ability to organize, summarize, and analyze experimental results, as well as optimize experimental procedures.
  - (3) Possess the ability to recognize and identify potential problems in practical engineering and structures, and the ability to collaborate with teams to solve engineering problems.

	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
<b>Class Schedule &amp; Requirements &amp; Course Objectives</b>	Introduction	Introduction to Mechanical Properties and Their Influencing Factors; Tensile Curve and True Stress-True Strain Curve; Measurement Standards	6	Lectures	Twice hand-in	Mastering Material Mechanics Performance Indicators and Measurement Concepts; Mechanical Performance Testing Standards
	Elasticity	Elasticity:, Viscoelasticity, Pseudo elasticity	8	Lectures + Experiments	Twice hand-in	Master Elastic Parameters, Anisotropy, Factors Affecting Elasticity,

						Viscoelasticity, Internal Friction, Pseudoelasticity, and Shape Memory Effect
	Plasticity	Plastic Deformation Mechanisms; Material Strengthening Mechanisms; Hardness	10	Lectures	Three hand-in	Understanding the Nature of Plastic Deformation, Strengthening Methods, Hardness Measurement
	Fracture	Fracture Mechanisms; Linear Elastic Fracture Mechanics	6	Lectures	Twice hand-in	Understanding Linear Elastic Fracture Mechanics, Fracture Toughness Concepts and Measurement
	Fatigue	Cyclic Loading; High Cycle Fatigue; Low Cycle Fatigue; Fatigue Design	6	Lectures	Twice hand-in	Understanding Fatigue Concepts, Fatigue Design, Fatigue Life Prediction
	Creep	High-Temperature Mechanical Behavior; Creep Mechanism; Creep Resistance Design	4	Lectures + Experiments	One hand-in	Understanding Creep Mechanism, Deformation Mechanism Maps, High-Temperature Material Design, Creep Life Prediction
	Dynamic Mechanical Behavior	Stress Waves; Mechanical Behavior under High-Speed Loading	4	Lectures	One hand-in	Understanding How Material Mechanical Performance Parameters Change with Loading Rate
	EIC	Stress Corrosion; Hydrogen Embrittlement; Liquid Metal Embrittlement	2	Lectures	One hand-in	Understanding the Intrinsic Reasons and Analysis of Material Performance Changes Under the Combined Action of Environment and Loading, Characterization Methods, and Preventive Measures
	Wear	Friction Mechanics; Wear Mechanisms; Wear Resistance Design	2	Lectures	One hand-in	Understanding Friction and Wear Mechanisms, Characterization Analysis, Prevention Measures
Grading	20% Assignments + 20% Quizzes + 10% In-class performance + 50% Final exam					
Textbooks & Other Materials	(1) Marc Meyers and Krishan Chawla, <i>Mechanical behavior of Materials</i> . 2 <sup>nd</sup> Edition, Cambridge University Press, 2009. (2) M. Ashby, H. Shercliff, and D. Cebon, <i>Materials: Engineering, Science, Processing and Design</i> . 3 <sup>rd</sup> edition, Butterworth-Heinemann (Elsevier).					

	(3) Lingti Kong, <i>Mechanical Behavior of Materials</i> , lecture notes.
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## Syllabus of “Principles of Materials Processing”

### Course Information

Course Code	MSE3612	Credit Hours)	80	Credits	5.0
Course Name	Principles of Materials Processing				
Course Type					
Target Audience					
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite			post		
Instructor	Ke Chen	Course Webpage			
Description	<p>This course is a compulsory subject fundamental course for the undergraduate students in the Materials Science and Engineering program. It teaches the basic principles and knowledge on the subjects of materials processing processes including liquid solidification and casting, plastic processing and forming of solid materials, and solid-state phase transformations and heat treatment of metals. It provides an opportunity for students to learn systematically and master the fundamental theoretical knowledge of materials science principles related to microstructural evolution and shape formation in the processes of making metallic materials and components by liquid casting, plastic forming and heat treatments. It involves the application of fundamental theoretical knowledge to industrial production practice. The course emphasizes on improving the students' ability to solve practical problems, and raising the students' interests and scientific ability in conducting research and development of new materials and new materials forming technologies. The teaching of this course will utilize English in lecturing, class discussions, tutorials, course work and assessments. The course employs a student-oriented teaching approach, encourages students to do prior preparation and thinking on the course contents to be learnt and utilize the modern information technologies to create a platform and environment for teacher-student interactions.</p>				
Course objectives and contents					
Course Object	<p>After completing the course, students should:</p> <ol style="list-style-type: none"> <li>(1) Learn about the microstructural evolution that occur during solidification processing, plastic forming and solid-state phase transformations of metallic materials.</li> <li>(2) Understand the fundamental scientific principles underlying the microstructural evolutions in solidification processing, plastic forming and heat treatments of metallic materials and the basic relationships between processing conditions and microstructures.</li> <li>(3) Understand the basic mechanics principles and the basic stress-strain relationships underlying the plastic forming of metallic materials.</li> <li>(4) Understand the basic elements of applying fundamental theoretical knowledge to related industrial production practice.</li> </ol>				

	(5) Improve the abilities of applying theoretical knowledge in analyzing related engineering problems and developing solutions, and the ability of communication in English.					
Class Schedule & Requirements & Course Objectives	Chapter	Contents (key points)	Credit Hours	Teaching Form	Assignments & Assessments	Objectives
	1	Introduction to Principle of Metal Processing and the Important of Solidification	2	In-class teaching	Assignments	
		Transport phenomena	3	In-class teaching	Assignments	
		Liquid Structure and Liquid Properties	2	In-class teaching	Assignments	
		Nucleation in Liquid	3	In-class teaching	Assignments	
		Solidification of Pure Metals	3	In-class teaching	Assignments	
		Solidification of Single-Phase Alloys	5	In-class teaching	Assignments	
		Solidification of Multi-Phase Alloys	4	In-class teaching	Assignments	
		Metal Casting Technology	3	In-class teaching	Assignments	
		Additive Manufacturing and Rapid Solidification	2	Experiment	Assignments	
	2	Introduction to Plastic Forming	3	In-class teaching	Assignments	
		Metallurgical Foundation of Plasticity	4	In-class teaching	Assignments	
		Stress Analysis	4	In-class teaching	Assignments	
		Strain Analysis	2	In-class teaching	Assignments	
		Yield Criteria	4	In-class teaching	Assignments	
		Constitutive Equations	2	In-class teaching	Assignments	
		Slab Method for Forming Analysis	2	In-class teaching	Assignments	

	Upper Bound Method for Forming Analysis	3	In-class teaching	Assignments			
	Plastic Forming Techniques and Mechanical Testing	2	Experiment	Assignments			
	3	Fundamentals of Phase Transformation in Solids	4	In-class teaching	Assignments		
		Reverse Eutectoid Transformations	3	In-class teaching	Assignments		
		Eutectoid Transformations	4	In-class teaching	Assignments		
		Martensitic Transformations	5	In-class teaching	Assignments		
		Bainite Transformations	4	In-class teaching	Assignments		
		Precipitation and Aging	3	In-class teaching	Assignments		
		Tempering of Ferrous Martensite	2	In-class teaching	Assignments		
		Heat Treatment of Large Castings and Forgings: Microstructures and Properties, and Process Control	2	Experiment	Assignments		
Evaluation of the achievement of course objectives	Objectives	Ordinary coursework (20 points)	Course Programs (30 points)	Final exam (50 points)	Course objective weight	Degree of achievement of course objectives	
	Assessment Methods						
Grading	Assignments (20%) + Quizzes (20%) + Final exam (60%)						

Textbooks & Other Materials	<ol style="list-style-type: none"><li>1. Phase Transformations in Metals and Alloys, D.A. Porter and K.E. Easterling, CRC Press, 2nd edition, 2004</li><li>2. Mechanical Metallurgy, George Dieter, McGraw-Hill Book Co., New York 1986</li></ol>
More	
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## Syllabus of “Fundamentals of Materials Science II”

Course Information						
Course Code	MSE2606	Credit Hours	48	Credits	3.0	
Course Name	Fundamentals of Materials Science II					
Course Type	Required course					
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite			post			
Instructor	Qiang Guo	Course Webpage	<a href="http://ocw.sjtu.edu.cn/G2S/OCW/cn/CourseDetails.htm?Id=343">http://ocw.sjtu.edu.cn/G2S/OCW/cn/CourseDetails.htm?Id=343</a>			
Description	<p>“Fundamentals of Materials Science” is one of the core curriculum for university/college students in the discipline of materials and metallurgy. The basic fundamentals of materials science are presented by lectures, experiments, class discussions, and extracurricular practice teaching, <i>etc.</i> In order to investigate the common laws for materials, the focus is on the internal relationships among the processing, structure, properties and performance for three different materials: metals, ceramic and polymer physics. The course provides guidance for materials design and application and lays a solid theoretical foundation for subsequent courses, materials science research and engineering technology.</p>					
Course objectives and contents						
Course Object	<p>(1) The fundamentals and frontiers of materials science &amp; engineering (A3)</p> <p>(2) Systematic knowledge on the structure-property-processing-characterization tetrahedral (A5.4)</p> <p>(3) The capability of discovering, analyzing and solving problems (B2); The ability for sustained learning (B7)</p> <p>(4) Use of professional English for problem-solving and effective communication (B1)</p>					
Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	1	Introduction	1	Lecture	General knowledge	1
	2	Fick’s diffusion laws	2	Lecture/discussion	Deep understanding	1,2,3
	3	Application of Fick’s laws	2	Lecture/discussion	Understanding and	1,2,3,4

4	Kirkendall effect and Darken equation	2	Lecture/discussion	Deep understanding	1,2,3,4
5	Solution to diffusion problems where diffusivity is	1	Lecture	Understanding	1,3,4
6	Thermodynamics of diffusion	1	Lecture	Deep understanding	1,2,3,4
7	Atomic mechanism of diffusion	2	Lecture/discussion	Deep understanding	1,2,3,4
8	Diffusion in ionic solids, ceramics and the molecular	2	Lecture	Deep understanding	1,2,3,4
9	Case study in diffusion	1	Lecture/discussion	Deep understanding	1,2,3,4
10	Thermodynamics of phase diagrams	3	Lecture/discussion	Deep understanding	1,2,3,4
11	Fundamentals of phase diagrams	1	Lecture	Understanding	1,4
12	Single phase diagrams	1	Lecture/discussion	Deep understanding	1,2,3,4
13	Simple binary phase diagrams	5	Lecture/discussion	Deep understanding	1,2,3,4
14	SiO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub> phase diagram	1	Lecture	Understanding	1,2,4
15	Fe-C phase diagram	3	Lecture/discussion	Deep understanding	1,2,3,4
16	Fundamentals of ternary diagrams	2	Lecture/discussion	Deep understanding	1,2,3,4
17	Immiscible ternary eutectic phase diagrams	2	Lecture/discussion	Deep understanding	1,2,3,4
18	Ternary eutectic phase diagrams with limited	2	Lecture/discussion	General knowledge	1,3,4
19	Other ternary phase diagrams	1	Lecture	General knowledge	1,4
20	Introduction of solid state phase transformations	3	Lecture	Understanding	1,2,3,4
21	Characteristics of solid state phase transformations	4	Lecture/discussion	Deep understanding	1,2,3,4
22	Nucleation & growth	4	Lecture/discussion	Deep understanding	1,2,3,4
23	Kinetics of phase transformations	2	Lecture	Understanding	1,3,4

	24	Experiment	8	Experiment	Experiment report	1,2,3,4
Grading	The final grade includes class participation, homework, experiments, and exams: (1) Class participation and homework : 20%; (2) Experiments: 20%;					
Textbooks & Other Materials	Title	Authors	Publication	Publication	Version	Book
	Introduction to Dislocations	Hull & Bacon	Elsevier		5th	
	Introduction to Material Science	A. G. Guy	McGraw-Hill, New York	1972-01-15 22:34:11	1	
	Fundamentals of Materials Science & Engineering	W. D. Callister, Jr.	John Wiley & Sons, Inc.	2001-01-15 22:31:43	5th Edition	
	Introduction to thermodynamics of materials	D. R. Gaskell	Taylor & Francis	2008-01-15 22:35:07	5th	
	Modern Physical Metallurgy	R. E. Smallman	ed. Butterworths, London	1985-01-15 22:33:18	4th	
	Phase Transformations in Metals and Alloys	D.A. Porter and K.E. Easterling,	CRC Press	2004-01-29 00:56:56	2	
	《材料科学基础(第三版)》	胡赓祥、蔡珣、戎咏华	上海交通大学出版社		1	
More	(1) Course instructional website, instructional reference website: <a href="http://ocw.sjtu.edu.cn/G2S/OCW/cn/CourseDetails.htm?Id=343">http://ocw.sjtu.edu.cn/G2S/OCW/cn/CourseDetails.htm?Id=343</a> (2) Based on the requirements of the Academic Code, follow the SJTU Code of Ethical Conduct, Assignment					
Notes						

<b>Syllabus of “Mechanics of Materials”</b>						
Course Information						
Course Code	MSE2603	Credit Hours	64	Credits	4.0	
Course Name	Mechanics of Materials					
Course Type	compulsory					
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite		post				
Instructor	Zhang Haiming	Course Webpage	<a href="https://oc.sjtu.edu.cn/courses/52646">https://oc.sjtu.edu.cn/courses/52646</a>			
Description	<p>Mechanics of Materials is the science of applying materials in engineering structures. It focuses on the relationship between deformation and force, the design of typical structures, and making full use of load sustaining capacity of the materials. The course provides the theoretical basis and calculation method for designing safe and economical engineering structures with specified requirements of strength, stiffness, and stability. The course consists of three modules: 1. the basic mechanical properties of materials as well as their measuring methods, the analysis of basic deformations of bars under tension, compression, shear, torsion, and bending, as well as the criterion of yielding and failure of materials; 2. Stress analysis and measurement in complex stress state; 3. Engineering application subjects enable students with the ability of analysis from materials to structures, including indeterminate structural analysis, fatigue analysis, buckling analysis of columns, and deformation analysis of structures. By studying this course, students should master the basic testing methods of material properties, basic engineering structure analysis methods in the process of material service, master the basic knowledge of the rational application of materials, and build a bridge from materials to engineering structures.</p>					
Course objectives and contents						
Course Object	<ol style="list-style-type: none"> <li>1. Understand the basic knowledge and cutting-edge knowledge of material application, and improve students' engineering awareness; (A3)</li> <li>2. Master the basic knowledge and engineering practical skills of working as an engineer; (A5.2)</li> <li>3. Master the testing methods of basic mechanical properties of materials and their usage in engineering applications; (A5.4)</li> <li>4. Have an ability to apply knowledge to analyze and solve practical problems; (A5.5)</li> <li>5. Have a sense of innovation, and master the comprehensive use of theory and technical means to carry out</li> </ol>					
Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives

Class Schedule & Requirements & Course Objectives	Chapter 1	Introduction to Mechanics of materials. The basic assumptions and types of material deformation under the action of force; The definition and expression of internal force, stress, and strain; Hooke's law under unidirectional elastic deformation; The basic form of deformation of components	3	classroom teaching	calculation and understanding	A3、 A5.2、 B15
		Basic equation and analysis method of static equilibrium (supplement the knowledge of theoretical mechanics)	1			
	Chapter 2	Internal forces and stresses during axial tension and compression, mechanical properties of materials during tension and compression	2	classroom teaching	calculation and understanding	A3、 A5.2、 B15
		Test methods and experiments of mechanical properties of materials		experiment	understanding and operation	A5.2、 A5.4
		Deformation, strength and stiffness design, deformation energy, and deformation calculation method based on deformation energy of tension and compression rod				
		Statically indeterminate problems in tension and compression, stress concentration. Practical analysis methods for engineering shear problems				
	Chapter 3	Torsion and torque diagram of shafts, torsion analysis of thin-walled cylinders, concept of pure shear deformation	2	classroom teaching	calculation and understanding	A3、 A5.2、 B15
		Stress and deformation of circular shaft during torsion, design conditions of shafts	1			

		Stress of close-coiled helical springs				
	Chapter 4	The relationship between the bending internal force and the internal force diagram, the transverse load distribution density, shear force, and bending moment of beams	4	classroom teaching	calculation and understanding	A3、A5.2、B15
		The cross section stress of the beam during bending, the strength design of the beam, and the measures to improve the bending strength of beams				
	Chapter 5	The approximate differential equation of deflection and its solving method, the superposition method to find the deformation of beams, the solution of the simple statically indeterminate beam, and the measure to improve the bending stiffness of beams.	5	classroom teaching	calculation and understanding	A3、A5.2、B15
	Chapter 6	The concept of column stability, the critical force of slender columns, the critical force of general columns, the measures to improve the anti-instability of columns	4	classroom teaching	calculation and understanding	A3、A5.2、B15
	Chapter 7	The concept of principal stress and the stress transformation formula in plane stress state; The concept of principal strain and the strain transformation formula in plane strain state; The concept of principal stress in three-dimensional (3D) stress state	4	classroom teaching	calculation and understanding	A3、A5.2、B15

		Application of Mohr's circle method in the analysis of stress and strain transformations	2	experiment	understanding and operation	A5.2、 A5.4
		Generalized Hooke's law; Method and application of strain gauge for stress measurement				
		Stress test (strain gauge test with elastic modulus)				
		Failure criteria for materials (4 strength theories)				
	Chapter 8	Principle of virtual displacement; The method of solving the deformation of components based on the principle of virtual work (introducing the unit load method and the graph multiplication method of solving the deformation)	4	classroom teaching	calculation and understanding	A3、 A5.2、 B15
	Chapter 9	Advanced topics and improvement: Fatigue failure of structure and analysis method; Impact problem and its analysis and solution method;	6	classroom teaching	calculation and understanding	A3、 A5.2、 B15
	Chapter 10	Topics and Improvements: Plastic deformation of member: stress-strain relationship of plastic deformation under uniaxial stress; Plastic deformation analysis of tensile rods; Plastic hinges of circular shaft; Plastic bending and plastic hinges; The concept of residual stress.	4	classroom teaching	calculation and understanding	A3、 A5.2、 B15

Class Schedule & Requirements & Course Objectives	Course Design	Course practice: Bicycle design (no longer solve the static indeterminate problem, mainly based on load-based testing, or the teacher gives the internal force calculation method of the frame structure), stress analysis and testing, material selection method, key parts analysis, gear disc shaft design	4	practice and experiment	calculation and understanding	A5.2、A5.5、B2
Grading	Final exam results: 70% Daily performance and experiment reports: 15% Course design: 15%					
Textbooks & Other Materials	Title	Authors	Publication	Publication	Version	Book
	Mechanics of Materials	James M. Gere; Barry J. Goodno	Cengage Learning	2018-01-01	Ninth Edition	
	材料力学（上下册）	刘鸿文	Higher Education Press	2017-07-01	Sixth Edition	
More						
Notes						

## Syllabus of “Thermodynamics of Materials”

### Course Information

Course Code	MSE2604	Credit Hours	48	Credits	3.0	
Course Name	Thermodynamics of Materials					
Course Type	Required course					
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite		post				
Instructor	Peng Zhang	Course Webpage				
Description	<p>This course introduces the fundamental concepts/theories on the thermodynamics of materials, from the basic concepts of enthalpy, entropy, free energy, and the basic laws of thermodynamics, to the behaviors of the systems including equilibrium, phase transformation, chemical reactions, mixing, cooling etc. Statistic thermodynamics is also introduced to explain the basic rules of thermodynamics from the microscopic aspect. Topics include: First, Second, and Third Law of thermodynamics, concepts of systems, Gibbs free energy, equilibrium, solution, dilute solutions, mixing, phase equilibrium, phase rules, phase diagrams, statistical mechanics, and surface phenomena. Specific applications and problem solving of these basic concepts in air conditioning, battery electrodes, desalination, and metallurgy etc. are also discussed.</p>					
Course objectives and contents						
Course Object	<ol style="list-style-type: none"> <li>1. To understand the fundamental and basic principles of thermodynamics (A5.3) .</li> <li>2. To learn to apply the basic principles and methods of thermodynamics in the study and the R&amp;D of materials (A3) .</li> <li>3. To understand the phase rules and the phase diagrams, as well as the application of the phase diagrams in materials study (A5.3) .</li> <li>4. To cultivate the ability of discovering the potential of existing materials and of developing new materials (B3) .</li> </ol>					
Class Schedule & Requirements & Course Objectives)	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	The First Law	The First Law	4	Lecture	Question answer and principle understanding	1

The Second Law	The Second Law	4	Lecture	Question answer and principle understanding	1
Relationship of thermodynamic properties of a system	Relationship of thermodynamic properties of a system	4	Lecture	Question answer and principle understanding	2
Equilibrium	Equilibrium	2	Lecture	Question answer and principle understanding	2
Chemical Equilibrium	Chemical Equilibrium	2	Lecture	Question answer and principle understanding	4
Electrochemistry	Electrochemistry	4	Lecture	Question answer and principle understanding	1
experiment	experiment	2	lab	report	NA
midtem	midtem	2	exam	NA	NA
Solution	Solution	6	Lecture	Question answer and principle understanding	1
Phase Rule	Phase Rule	2	Lecture	Question answer and principle understanding	3
Phase Diagrams	Phase Diagrams	6	Lecture	Question answer and principle understanding	3
Statistical Thermodynamics	Statistical Thermodynamics	4	Lecture	Question answer and principle understanding	1
Experiment	Experiment for thermochemistry	2	lab	report	4

	Interface and Surface Thermodynamics	Interface and Surface Thermodynamics	4	Lecture	Question answer and principle understanding	4
Grading	Home assignments (20%); Quizzes and class performance (10%); Midterm exam (30%);					
Textbooks & Other Materials	Title	Authors	Publication	Publication date	Version	Book number
	Thermodynamics Materials	of David Rangone	V. John Wiley & Sons, Inc		1	
More						
Notes						

## Syllabus of “Structural and Chemical Characterization of Materials”

Course Information					
Course Code	MSE3610	Credit Hours	64	Credits	4.0
Course Name	Structural and Chemical Characterization of Materials				
Course Type	Compulsory course				
Target Audience	Junior undergraduates				
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science and Engineering (1) and (2)	post	Graduation thesis		
Instructor	Lanting Zhang	Course Webpage			
Description	<p>One of the key jobs in materials research is to understand the chemistry-microstructure-property relationship in materials. This requires a comprehensive knowledge of the chemical composition, crystal structure and microstructure of a specimen besides the mechanical and/or physical properties. When a piece of specimen is available, the curiosity of human being often leads to questions such as "what" and "how". To answer these curiosities, a proper characterization of the specimen is required, either chemically or physically. In this course, topics at an undergraduate level will cover X-ray diffraction, microscopy and spectroscopy methods, which are important means to determine the structure, morphology and chemistry of materials.</p> <p>This course is mandatory for four-year junior undergraduate students majoring in materials science and engineering. Topics include X-ray diffraction method, optical microscopy, electron microscopy and spectroscopy methods, with emphases on understanding the analysis methods that are of common interest to researcher in materials science and engineering. The students are required to master the basic experimental technique, specimen preparation technique and analysis technique to carry out the experiments and analyze the results properly.</p> <p>Lectures are offered weekly in one semester (two lectures/week, 16 weeks in total). Three experiments (XRD, TEM and SEM) are included in the course besides the lectures. Through the systematic learning of this course, students will possess solid theoretical foundations and practical skills in material organization and structure characterization, laying a solid foundation for future work in material research, development, production, and application.</p>				
Course objectives and contents					
Course Object	<ol style="list-style-type: none"> <li>1. Be familiar with the basic principles and methods of structural and chemical characterizations, including microscopy observation, diffraction analysis, spectroscopy and other techniques. Students will be able to select and apply characterization techniques correctly.</li> <li>2. Learn to use advanced experimental equipment and software tools to conduct materials characterization experiments and to interpret the experiment results correctly.</li> <li>3. Cultivate students' innovative consciousness and practical abilities in the field of materials research and</li> </ol>				

	development, enabling them to comprehensively apply the knowledge learned to solve practical problems and improve material design and development capabilities.					
	4. Be able to communicate technical options both in Chinese and English, with a knowledge of latest developments of the analysis and testing methods covered in this course in research and development of materials.					
Class Schedule & Requirements & Course Objectives	Chapter	Content	Lecture hour	Form of teaching	Assignment and Assessment Requirements	Objectives
	1.	Introduction and Crystallography	2	Lecture	Quiz	
	2.	Physics of X-ray	2	Lecture	Quiz	
	3.	Generation of X-ray	2	Lecture	Quiz	
	4.	Bragg's law	2	Lecture	Quiz + assignment	
	5.	Diffraction intensity	2	Lecture	Quiz	
	6.	Powder diffraction method	2	Lecture	Quiz	
	7.	Phase identification	2	Lecture	Quiz	
	8.	Precious determination of lattice constant	2	Lecture	Quiz + assignment	
	9.	Strain/stress analysis	2	Lecture	Quiz	
	10.	X-ray diffraction experiment	2	Experiment	Experiment report	
	11.	Optical principles and resolution	2	Lecture	Quiz	
	12.	Preparation metallographic specimens	2	Lecture	Quiz + assignment	
	13.	Bright field, dark field, polarized light microscopy	2	Lecture	Quiz	
	14.	Confocal scanning microscopy	2	Lecture	Quiz, Mid-term exam	
	15.	Principles of electron optics and resolution	2	Lecture	Quiz	
16.	Specimen preparation for transmission electron microscope	2	Lecture	Quiz		

Class Schedule & Requirements & Course Objectives	17	Selected-area diffraction and camera length	2	Lecture	Quiz	
	18	Indexing of polycrystal SAD pattern	2	Lecture	Quiz	
	19	Indexing of single crystal SAD pattern	2	Lecture	Quiz	
	20	Kikuchi lines	2	Lecture	Quiz	
	21	Imaging modes and image contrast in TEM	2	Lecture	Quiz	
	22.	Diffraction contrast - 1	2	Lecture	Quiz	
	23	Diffraction contrast - 2	2	Lecture	Quiz	
	24	Imaging lattice defects using diffraction contrast	2	Lecture	Quiz	
	25	Phase contrast and high-resolution TEM	2	Lecture	Quiz	
	26.	TEM experiment	2	Experiment	Experiment report	
	27	Structure of scanning electron microscope, beam-specimen interaction	2	Lecture	Quiz	
	28	Imaging principles and imaging contrast in SEM	2	Lecture	Quiz	
	29	Back-scatter electron diffraction in SEM	2	Lecture	Quiz	
	30	X-ray spectroscopy microanalysis	2	Lecture	Quiz	
	31	EDS/WDS in TEM&SEM	2	Lecture	Quiz	
32	SEM experiment	2	Experiment	Experiment report, final exam		
Grading	Final exam (30%) + Mid-term exam (30%) + Homework & quiz(30%) + Experiment report(10%)					
Textbooks & Other Materials	Title	Authors	Publication	Publication date	Version	Book number

	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods	Yang Leng	Wiley	2013-08-02	2nd Edition	
More						
Notes						

## Syllabus of “Materials Physics”

### Course Information

Course Code	MSE3607	Credit Hours	64	Credits	4.0	
Course Name	Materials Physics					
Course Type	Required					
Target Audience	Juniors in the School of Materials Science and Engineering					
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite	Calculus, General Physics, Fundamental of Materials Science	post				
Instructor	Jiajun Gu	Course Webpage				
Description	Materials Physics is a fundamental course in materials science. After the course, students can master some basic concepts of solid state physics, such as periodic structure of crystals, lattice vibration, free electron gas, and energy bands theory. They can also understand the relationship between physical phenomena such as mechanics, electricity, optics, and magnetism in materials and material structures by using these theories.					
Course objectives and contents						
Course Object	<ol style="list-style-type: none"> <li>1. Master the basic concepts and theories of material physics</li> <li>2. Gain the ability to apply mathematical and physical methods to analyze and solve materials science problems.</li> <li>3. Gain the ability to collect, analyze, handle information.</li> <li>4. Develop students' innovation and creativity in basic research of material physics.</li> <li>5. Promote students to following scientific frontiers and broadening scientific perspective.</li> <li>6. Develop students' academic interests and patriotism.</li> </ol>					
Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	Introduction	Introduction	2	Teaching	Homework	Course Object 6
	Chapter 1	Crystal Structure	6	Teaching	Homework	Course Object 5
	Chapter 2	Crystal Diffraction	8	Teaching	Homework	Course Object 6
	Chapter 3	Crystal Bonding	4	Teaching	Homework	Course Object 1,2,4
	Chapter 4	Crystal Vibrations	6	Teaching	Homework	Course Object 1,2,4

Chapter 5	Thermal Properties of	6	Teaching	Homework	Course Object 1,2,4	
Chapter 6	Free Electron Fermi Gas	6	Teaching	Homework	Course Object 1,2,4	
Chapter 7	Energy Bands	10	Teaching	Homework	Course Object 1,2,4	
Chapter 8	Fundamentals of Semiconductors	8	Teaching	Homework	Course Object 1,2,4.	
Chapter 9	Dielectric Properties of crystals	4	Teaching	Homework	Course Object 1,2,4	
Experiment	Ultraviolet spectroscopy for semiconductor bandgap measurement.	4	Experiment	Experimental Report	Course Object 3	
Grading	(1) Lecture Attendance & Homework (30%) (2) Final Examination (70%)					
Textbooks & Other	Title	Au	Publication	Publication date	Version	Book
	Introduction to Solid State	C.	John (Wiley & Sons, Inc.		8th edition	
More						
Notes						

## Syllabus of “Physical Properties of Materials”

Course Information						
Course Code	MSE3611	Credit Hours	32	Credits	2.0	
Course Name	Physical Properties of Materials					
Course Type						
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite		post				
Instructor	Tao Peng	Course Webpage				
Description	<p>This course covers key concepts, fundamental theories, characterizations and applications of various physical properties of materials including optical, thermal, electrical and magnetic properties. Topics include optical interactions with materials, optical coupling effects, thermal conductivity, thermal expansion and thermal coupling effects, electrical conductivity and dielectric theory, electric coupling effects, ferromagnetic properties and magnetic coupling effects. Based on the understanding of the fundamentals of these physical properties, representative metallic, ceramic, polymeric and composites materials are selected to introduce optical, thermal, electrical, magnetic functional materials as well as their device-level and system-level applications. special attention is focused on the relationship between composition, microstructure, processing, and physical properties of materials.</p>					
Course objectives and contents						
Course Object	<ol style="list-style-type: none"> <li>1. To teach students to fully understand the key concepts, basic theory, basic characterization and typical applications of physical properties of materials;</li> <li>2. To teach students to have solid understanding of the relationship between materials' composition, structure, characterization, processing and physical properties for functional materials;</li> <li>3. To train students' capabilities in logic, innovative, independent and critical thinking, discovering, analyzing and solving scientific problems;</li> <li>4. To improve students' proficiency in literature searching and reading, scientific writing and communication in English;</li> <li>5. To cultivate students' self-regulating and lifelong learning capabilities, team-work collaboration soft skills</li> </ol>					
Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	Introduction	Basic understanding of materials science and physical properties	2	Lecture	Question answer and principle understanding	3, 4

Optical properties	Understand key thermal properties including refractive index, light-matter interaction, polarization and working principles of lasers and the corresponding physical mechanism	6	Lecture	Question answer and principle understanding	1, 2, 3, 4, 5
Thermal properties	Understand key thermal properties including heat capacity, thermal conductivity, thermal expansion coefficient and the corresponding physical mechanism	4	Lecture	Question answer and principle understanding	1, 2, 3, 4, 5
Electrical properties	Understand key electrical properties including electron conduction theory, semiconductor; p-n junction and semiconducting devices, dielectrical properties and their physical mechanism	8	Lecture	Question answer and principle understanding	1, 2, 3, 4, 5
Magnetic properties	Understand key magnetic properties and the corresponding physical mechanism	4	Lecture	Question answer and principle understanding	1, 2, 3, 4, 5
Comprehensive experiments on optical and thermal properties	Being able to carry out experiments, analyze the results based on the learnt knowledge on optical and thermal properties of materials	2	Experiment	Experimental report	3, 4, 5
Comprehensive experiments on electrical and magnetic properties	Being able to carry out experiments, analyze the results based on the learnt knowledge on electrical and magnetic properties of materials	2	Experiment	Experiment report	3, 4, 5
Review and key concepts presentation	To fluently present understanding of key concepts in front of others; Clearly and correctly answer	4	Oral presentation	Question answer	3, 4, 5

Grading	Homework (20%) Class performance and In-class quizzes (10%) Experiment (10%) Presentation(10%) Final exam (50%)					
Textbooks &Other Materials	Title	Authors	Publication	Publication	Version	Book
More						
Notes						

## Syllabus of “Composite Materials”

### Course Information

Course Code	MSE4705	Credit Hours	48	Credits	3.0
Course Name	Composite Materials				
Course Type					
Target Audience					
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite		post			
Instructor	Guo Qiang	Course Webpage			
Description	<p>It is intended that this course provides the student with a clear and thorough presentation of the theory and application of the principles of composite materials.</p> <p>The subject matter is organized into 11 chapters. The chapter 1 begins with the introduction of the conception, classification, basic properties, and design principles of composite materials. In chapter 2, the fabrication and properties of the various types of reinforcements are described with a special emphasis on microstructure-property correlations. This is followed by a chapter (Chap.3) on the three main types of matrix materials, namely, polymers, metals, and ceramics. It is becoming increasingly evident that the role of the matrix is not just that of a binding medium for the reinforcements but it can contribute decisively toward the composite performance. Furthermore, Chapter 4 discusses a general description of the interface in composites, and how the interface structures affect the composite properties. Then, a detailed description is given of some of the important types of composites, including polymer matrix composites (Chap.5), metal matrix composites (Chap.6), ceramic composites (Chap.7), and carbon fiber composites (Chap.8), for their microstructure characteristics, processing technologies and application fields. Finally, Chapter 9 has discussed the micro mechanics, and Chapter 10 has involved with macro mechanics of composites are described in detail. Finally, Chapter 11 has described of strength and fracture modes in composites. These three chapters are emphasizing the theme of how the (micro and macro) structures control the properties.</p>				
Course objectives and contents					
Course Object	<ol style="list-style-type: none"> <li>1. To acknowledge the definition, classification, basic properties, and design principles of composite materials.</li> <li>2. To obtain the classification, microstructural characteristics, physical properties, fabrication strategies and application fields of the various types of reinforcements and matrix materials.</li> <li>3. To acknowledge the definition and interfacial effect of the interface in the composites; To understand the interfacial structures and characteristics, and their effects on the properties of composites.</li> <li>4. To learn the classification, microstructural characteristics-physical properties, fabrication methods and application fields of the polymer / metal /ceramics / nano matrix composites.</li> </ol>				

Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
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Class Schedule & Requirements & Course Objectives	Introduction of composite materials	To understand the importance and necessity of composites, and have a general idea about the basic concepts, history and applications of composites.	6	Lecture	Quiz, PPT Presentations & final exam	1. 2.
	Metal matrix composites	To have a deep understanding for the essence of MMCs from the definition, characteristics and application requirements.	14	Lecture and experiments	Quiz, PPT Presentations & final exam	2.3.4
	Ceramic matrix composites	To understand the two types of continuous fibers, the basic textile structures of fibers and fabrication methods of CMCs.	10	Lecture	Quiz, PPT Presentations & final exam	2.3.4
	Nanocomposites	To remember the definition, advantages and challenges of nanocomposites, and get a general idea about the characteristics of the nano-sized reinforcements.	4	Lecture	Quiz, PPT Presentations & final exam	2.3.4
Grading	The course assessment consists of three parts: the usual grade, the midterm grade and the final grade. The usual grade is the sum of five classroom quizzes and one lab report, of which the classroom quizzes account for 20% of the total grade and the lab report accounts for 10% of the total grade. The midterm examination is conducted in the form of group oral report, two students in a group, combined with the PPT to do a 10-minute oral report related to composite materials, the content of which is to introduce the characteristics of a new type of composite materials, processing methods and applications, the results account for 30% of the total grade. The final assessment is in the form of a closed-book examination, which accounts for 40% of the total grade.					
Textbooks & Other Materials	Title	Authors	Publication	Publication	Version	Book
	Composite Materials, Science and Engineering	Krishan K. Chawla	Springer		Third edition	
More						
Notes						

## Syllabus of “Materials Modeling and Computation”

Course Information					
Course Code	MT343	Credit Hours	48	Credits	3
Course Name	Materials Modeling and Computation				
Course Type	MSE elective course				
Target Audience	Seniors of SMSE@SJTU				
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science and Engineering	post			
Instructor	Prof. Xiongqi Peng Prof. Guisen Liu	Course Webpage			
Description	Materials Modeling and Computation aims to solve the problems in materials science and engineering by means of scientific computations based on physical models. This course covers three parts, namely, Molecular Dynamics (MD), Cellular Automaton (CA) and Finite Element Method (FEM). Based on the understanding of the principles and techniques of these three methods, popular software packages such as LAMMPS and ABAQUS will be introduced and applied to solve issues in materials science and engineering.				
Course objectives and contents					
Course Object	<ol style="list-style-type: none"> <li>1. Acquire basic knowledge of computational materials science and its application to materials development and performance prediction. (In support of graduation requirement 1.1)</li> <li>2. from microscopic, mesoscopic and then macroscopic scales, focusing on mastering microscopic scale MC simulation methods and the basis of physical quantity calculation, mesoscopic scale mastering CA calculation methods, and macroscopic scale mastering the calculation methods of FEM and the engineering practice problems that can be solved. (Support graduation requirement 3.1)</li> <li>3. use commonly used tools such as instrumentation, mapping, and simulation software to solve complex materials engineering problems, evaluate the correctness of simulation results and point out their limitations. (Support Graduation Requirement 5.3)</li> <li>4. master multiscale computer applications of materials behavior in the environment and production (supports graduation requirement 7.1)</li> </ol>				
Correspondence between graduation requirement indicator	objective	Graduation requirements target points			
	1	1.1 Possess the basic theoretical knowledge of mathematics, natural sciences, and specialties, professional knowledge, and experimental skills needed to solve complex engineering problems in materials science.			

points and course objectives	2	3.1 Knowledge of basic design/development methods and techniques for the full cycle and process of engineering design and product development, and understanding of the factors that influence design objectives and technical solutions.
	3	5.3 Develop or select modern tools such as instrumentation, mapping, and simulation software that meet specific needs to simulate and predict complex materials engineering problems, evaluating the validity of the simulation results and noting their limitations.
	4	7.1 Know and understand the concepts and implications related to production, design, research, development, environmental protection and sustainability in materials engineering practice.

Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Credit Hours	Teaching methods	Homework & assessment	Objectives
	Chapter 1	Introduction to the course and FEM	To understand the concepts of FEM and ABAQUS software package.	2	Lectures		4
	Chapter 2	FEM for Truss Element	To derive FE formulation for truss element and solve truss problems with own designed code or ABAQUS	4	Lectures + Tutorials	Show the FE method for truss problem; Write a formal report, submit with ABAQUS CAE file	1, 3
	Chapter 3	General FE Formulations for Solids	To understand the basic concepts of FEM for a general solid, including stress, strain, material model and FE equations.	4	Lectures		1, 2
	Chapter 4	FE for 2D Planar Element	To understand the FE formulation for 2D planar element. Know the general procedure and basic setting for solving 2D planar problem by using ABAQUS.	6	Lectures + Tutorials	Show the basic equations and submit a formal report along with code. Write a formal report, submit with ABAQUS CAE file	1, 3
	Chapter 5	Solve 3D solid Problem with	Know the general procedure and basic setting for solving	4	Lectures + Tutorials	Write a formal report, submit	1, 3

		ABAQUS	3D problem by using ABAQUS.			with ABAQUS CAE file	
Chapter 6	Solve contact Problem with ABAQUS	Know the general procedure and basic setting for solving 3D contact problem by using ABAQUS.	4	Lectures + Tutorials	Write a formal report, submit with ABAQUS CAE file	1, 3	
Chapter 7	Theory 1: force fields and calculation	Have a general idea of force fields and know how to calculate forces	2	Lectures	Question answer and principle understanding	1	
Chapter 8	Theory 2: Periodical Boundary Condition and potential functions in MD	To know PBC and minimum energy criterion, LJ, EAM potential functions	2	Lectures	Question answer and principle understanding	1	
Chapter 9	Theory 3: Integration of Newton's equation of motion	To know Verlet, leap-frog, and velocity Verlet algorithms for equations of atomic motion	2	Lectures	Question answer and principle understanding	1	
Chapter 10	Theory 4: MD ensemble	To know NVT, NVE ensembles	2	Lectures	Question answer and principle understanding	1	
Chapter 11	Experiments	To master typical means to calculate the energy change; To master the MD simulation method for the defects formation in crystal; To master the MD calculation method for lattice constants; To master the MD calculation method for the energy change calculation for different types of dislocation	8	Lectures + Tutorials	Write a formal report, submit with LAMMPS and OVITO file	2, 3	
Chapter 12	Introduction to CA	To master CA simulation of grain growth during heating processes To master the CA simulation of DRX in metals and alloys	2	Lectures + Tutorials	Question answer and principle understanding	4, 3	
Evaluation of the achievement	Objectives Assessment Methods			Ordinary coursework (20 points)	Course Programs (30 points)	Final exam (50 points)	Course objective Degree of achievement of

of course objectives					weight	course objectives
Grading	(1) Regular assignments 20 points (2) Course project 80 points					
Textbooks & Other Materials	1.The Art of Molecular Dynamics Simulation, D.C. Rapaport, Cambridge University Press, 2004, 2nd edition, ISBN: 9780511816581 2.Understanding Molecular Simulation, D. Frenkel and B. Smit, Elsevier Academic Press, 2010, 2nd edition, ISBN: 9780122673511 3. 《分子模拟—从算法到应用》,Frenkel & Smit, 汪文川译, 化学工业出版社, 2002, 第一版, ISBN:7502539522/TQ-1557 4. Concepts and Applications of Finite Element Analysis, R. Cook, et al., John Wiley & Sons, 1989, 4th edition, ISBN:9780471356059 5. Handbook of Materials Modeling, S. Yip, Dordrecht: Springer, 2005, 1st edition, ISBN:1402032870					
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# Syllabus of "Fundamentals of Materials Science I (Internationalization Pilot Course)" (2020 version)

## Course Information

Course Code	MSE2601	Credit Hours	48	Credits	4	
Course Name	Fundamentals of Materials Science I					
Course Type	Compulsory Course					
Target Audience	Undergraduate students majored in materials science & engineering, metallurgical engineering, mechanical engineering and electrical engineering					
Language of Instruction	English					
School	Materials Science & Engineering					
Prerequisite	College Physics, College Chemistry, Thermodynamics of Materials, Solid State Physics	post	Mechanical behavior of materials; Materials processing; Materials characterizations; Composite Materials			
Instructor	Guo Qiang	(Course Webpage)	<a href="https://www.coursera.org/learn/fundamentals-of-materials-science/home/info">https://www.coursera.org/learn/fundamentals-of-materials-science/home/info</a>			
Description	<p>“Fundamentals of Materials Science” is one of the core curriculum for university/college students in the discipline of materials and metallurgy. The basic fundamentals of materials science is presented by lectures, experiments, class discussions, and extracurricular practice teaching, <i>etc.</i> In order to investigate the common laws for materials, the focus is on the internal relationships among the processing, structure, properties and performance for three different materials: metals, ceramic and polymer physics. The course provides guidance for materials design and application and lays a solid theoretical foundation for subsequent courses, materials science research and engineering technology. This course is the first part of the course, and covers atomic bonding, crystal structures, defects in materials, mechanical properties and recrystallization.</p>					
Course objectives and contents						
Course Objectives	1、 Understanding of the fundamentals and frontiers of materials science & engineering 2、 Systematic knowledge on the structure-property-processing-characterization tetrahedron. 3、 Use of professional English for problem-solving and effective communication.					
Class Schedule & Requirements	Content	Duration (hours)	Type of teaching	Requirement	Type of evaluation	Corresponding course objective(s)
1	Introduction	1	Lecture	General knowledge	Homework	1

Course Objectives	2	Atomic structure	1	Lecture	General knowledge	Homework	1
	3	Chemical bonding	2	Lecture	Understanding	Homework/quiz	1
	4	Fundamentals of Crystallography	4	Lecture	Deep understanding	Homework/quiz	1
	5	Crystal structure of metals	4	Lecture	Deep understanding	Homework	1
	6	Structure of alloys	2	Lecture	Understanding	Homework	1
	7	Other crystal structures	2	Lecture	General knowledge	Homework	1
	8	Point defects	2	Lecture	Deep understanding	Homework/quiz	1
	9	Burgers vector of dislocations	3	Lecture	Understanding	Homework	1
	10	Elastic field and interactions of dislocations	3	Lecture	Understanding	Homework	1,2
	11	Movement of dislocations	3	Lecture	Understanding	Homework	1,2
	12	Surfaces and interfaces	2	Lecture	Deep understanding	Homework/quiz	1,2
	13	Elasticity of crystals	3	Lecture	Deep understanding	Homework/quiz	1,2
	14	Plastic deformation of single crystals and poly-crystals	2	Lecture	Deep understanding	Homework/quiz	1,2
	15	Influence of plastic deformation of alloys on properties	2	Lecture	Understanding	Homework	1,2
	16	Recovery, recrystallization and coarsening	2	Lecture	Deep understanding	Homework/quiz	1,2
	17	Dynamic recovery and recrystallization	2	Lecture	Understanding	Homework	1,2
	18	Experiment 1: Crystal structure with XRD measurement	2	Lab	Deep understanding	Lab report	1,2,3
	19	Experiment 2: tensile test	2	Lab	Deep understanding	Lab report	1,2,3
	20	Experiment 3: recrystallization microstructure of aluminum alloys	2	Lab	Deep understanding	Lab report	1,2,3
	21	Experiment 4: mechanical property evolution during recrystallization	2	Lab	Deep understanding	Lab report	1,2,3
	Grading	<p>(1) Homework and class participation: 20%</p> <p>(2) Experiments: 20%</p> <p>(3) Final exam: 60%</p>					

Textbooks & Other Materials	<ol style="list-style-type: none"> <li>1) W. D. Callister, Jr., Fundamentals of Materials Science &amp; Engineering, 5<sup>th</sup> Edition, John Wiley &amp; Sons, Inc. New York, 2001.</li> <li>2) 《材料科学基础(第三版)》, 胡赓祥、蔡珣、戎咏华编著, 上海交通大学出版社, 2010</li> <li>3) R. E. Smallman, Modern Physical Metallurgy, 4th ed. Butterworths, London, 1985</li> <li>4) A. G. Guy, Introduction to Material Science, McGraw-Hill, New York, 1972</li> <li>5) D. R. Gaskell, Introduction to thermodynamics of materials, 5<sup>th</sup> Edition, Taylor &amp; Francis, 2008</li> <li>6) D.V. Regone, Thermodynamics of materials, Volume I, John Wiley &amp; Sons, 1995</li> <li>7) Porter &amp; Easterling, Phase Transformations in Metals &amp; Alloys 2<sup>nd</sup> Edition, CRC Press, 1992</li> <li>8) R. W. Hertzberg, Deformation &amp; Fracture Mechanics of Engineering Materials, John Wiley &amp; Sons, 1976</li> <li>9) Hull &amp; Bacon, Introduction to Dislocations, 5<sup>th</sup> Edition, Elsevier, 2011</li> </ol>
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## Syllabus of “Science and technology of energy materials”

### Course Information

Course Code	MSE5618	Credit Hours	32	Credits	2.0	
Course Name	Science and technology of energy materials					
Course Type						
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite		post				
Instructor	Cui Kehang	Course Webpage				
Description	<p>The main problems of the 21st century are the environmental and energy issues. In this course, we elaborate on the principle and production applications of energy materials combined with the current issues of environmental and energy science and technology. We aim to cultivate students' scientific thinking and the preliminary ability to solve practical problems.</p> <p>The theories and applications of electrochemistry and catalysis have penetrated into modern life and various branches of energy and environment fields, and have shown great applications and prospects. For this reason, the main contents of this lecture include: energy and energy materials, solar photovoltaics, solar photothermal conversion, electrochemistry and energy storage, electrocatalytic hydrogen production and fuel cells, photocatalysis etc. Through this course, students can not only learn the basic knowledge of energy and environmental materials, but the comprehend the applications of these knowledge in the field of materials, environmental protection, clean energy, etc.</p>					
Course objectives and contents						
Course Object	<ol style="list-style-type: none"> <li>1. In-depth comprehension of fundamental principles and theories of energy materials; as well as the inherent relationships among processes, structures, properties and performance of energy materials. (For graduation requirement 1.1)</li> <li>2. Basic knowledge of the history, state of the art and future trend of energy materials. (For graduation requirement 1.2)</li> <li>3. Basic knowledge of material-related societal issues including the environment and sustainable development. (For graduation requirement 7.2)</li> <li>4. Basic knowledge of design, processing and manufacturing problems of energy materials, and applying appropriate theories to analyze and solve these problems. (For graduation requirement 2.2)</li> </ol>					
Class Schedule	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives

& Requirements & Course Objectives	Introduction to Energy Materials	basic concepts of energy and energy materials, including energy, energy materials, environmental issues, application, prospect and international policy of clean energy	2	lecture	in-class quiz	123
	Global Warming and Carbon Neutrality	science of global warming and the carbon cycle on Earth, as well as carbon capture, utilization, and storage (CCUS) technology	2	lecture	in-class quiz	13
Class Schedule & Requirements & Course Objectives	Solar photovoltaics	basic principles of photovoltaics and their applications, including solar energy resource, fundamentals of photovoltaics, some advanced concepts in photovoltaics, as well as modules and systems	6	lecture and experiment	lab report	1234
	Solar photothermal utilization	thermodynamics of photothermal conversion; working mechanism of solar thermal energy storage materials; fabrication and evaluation of solar thermal energy storage materials	6	lecture and experiment	lab report	1234
	Fundamental of Catalysis	basic principles of catalysis, and the applications of catalytic reforming of natural gases, including the catalysts for natural gas reforming: structure, synthesis, evaluation and research progress	2	lecture	in-class quiz	1234
	Electrocatalysis and photocatalysis	mechanisms of electrocatalysis and photocatalysis with fundamentals of semiconductor physics; photo- and electrocatalytic process of hydrogen generation	8	lecture and experiment	lab report	1234
	Energy storage materials and devices	mechanisms of electrochemical energy storage; mechanisms, devices and evaluation of lithium-ion batteries; materials for the cathode and anode of lithium ion batteries	6	lecture	in-class quiz	234
Grading	Major Assignment (40%); Summary PowerPoint (30%); Homework, Attendance, & Lab Report (30%)					
Textbooks & Other Materials	Title	Authors	Publication	Publication date	Version	Book
	新能源材料科学与应用技术	新能源材料科学与应用技术编委会	科学出版社		2016	

	Nanoscale Energy Transport and Conversion	Gang Chen	Oxford University Press		2005	
	The Physics of Solar Cells	Jenny Nelson	Imperial College Press		2003	
	能源材料—原理与应用	上官文峰、江治、屠恒勇、沈水云	上海交通大学出版社			
	Concepts of Modern Catalysis and Kinetics	I. Chorkendorff, J. W. Niemantsverdriet	Wiley		2017	
	Electrochemical Methods: Fundamentals and Applications	Allen J. Bard, Larry R. Faulkner	Wiley		2001	
More						
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## Syllabus of “Biomedical Materials”

Course Information					
Course Code	MT336	Credit Hours	48	Credits	3.0
Course Name	Biomedical Materials				
Course Type	Limited optional courses				
Target Audience					
Language of Instruction	English				
School	School of Materials Science and Engineering				
Prerequisite		post			
Instructor	Dou Hongjing	Course Webpage			
Description	<p>This course provides an introduction to the world of biomaterials, linking the fundamental properties of metals, polymers, ceramics and natural biomaterials to the unique advantages and limitations surrounding their biomedical applications. Clinical concerns such as sterilization, surface modification, cell-biomaterial interactions, drug delivery systems, biomedical diagnosis, and tissue engineering are discussed in detail, giving students practical insight into the real-world challenges associated with biomaterials engineering. Key definitions, equations and concepts are concisely summarized, allowing students to quickly and easily identify the most important information. The course covers: surface chemistry and physics of selected metals, polymers, and ceramics; characterization methodology; modification of biomaterials surfaces; quantitative assays of cell behavior in culture; biosensors and microarrays; bulk properties of implants; acute and chronic response to implanted biomaterials; drug delivery; and tissue engineering.</p> <p>In this course, students will learn how to apply the knowledge from basic material courses to identify material properties that are critical for metallic, polymer and ceramic biomaterials, or their combination. Besides, this course will teach basic physical, chemical and mechanical processes that may occur on biomaterials in use, suggest proper type of biomaterial for given applications, taking into account functions, health risk and even economic aspects. In addition, the course will cultivate the ability of designing new biomaterials and evaluating the potential of existing biomaterials.</p>				
Course objectives and contents					
Course Object	<p>Analyze and evaluate corrosion and degradation reactions that occur for different biomaterials and their consequences.</p> <p>Understand the basic knowledge of various biomedical materials, which include metallic, polymer and ceramic biomaterials, or their combination.</p> <p>Identify the proper method to perform property characterization for a given biomedical material and interpret the results from various measurements.</p> <p>Design biomedical materials according to the requirements of various application fields.</p>				

Class Schedule & Requirements & Course Objectives Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	1	Introduction to Biomedical Materials	2	Classes	Have a general understanding of biomedical materials.	1, 2
	2	Basic properties of biomaterials: bioceramics and bioglasses	4	Classes + Labs	Knowledge of basic concepts and classification of bioceramics; ability to select appropriate methods to characterize bioceramics; understanding of bioceramics related applications.	1, 2
	3	Basic Properties of Biomaterials: Metallic Biomaterials	4	Classes + Labs	Knowledge of the structure and properties of biometallic materials; ability to design biomedical metals as required.	1, 2
	4	Basic Properties of Biomaterials: Biopolymers	8	Classes	Have a basic knowledge of polymers, concepts, nomenclature and classification of biomedical polymers; be able to design biomedical polymers as required.	1, 2
	5	Biomaterial-tissue-organism interactions: metal corrosion and abrasion	4	Classes	Knowledge of corrosion mechanisms and corrosion test methods for metallic materials. Understand the impact of wear on medical devices and the wear resistance of biomaterials.	2, 3, 4
	6	Biomaterial-tissue-organism interactions: inflammatory reactions, carcinogenicity, hypersensitivity reactions	2	Classes	To understand the concepts of inflammatory reactions, biocompatibility, carcinogenicity and hypersensitivity reactions and their mechanisms due to material-tissue interactions.	2, 3, 4
	7	Protein adsorption on material surfaces	2	Classes	Understand and appreciate the structure (primary, secondary, tertiary and quaternary), isoelectric point and solubility of proteins.	2, 3, 4
	8	Cells and cell-biomaterial interactions	2	Classes	Understand the structure and function of cells. Understand cell-cell interactions and cell-biomaterial interactions.	2, 3, 4

9	Biocompatibility Evaluation	2	Classes + Labs	Understand cell culture and animal experiments relevant to the biological evaluation of materials.	2, 3, 4	
10	Artificial organs and tissue engineering	6	Classes + practice visits	Understand the structure and properties of natural tissues of the body. Understand biomaterials for organ repair and replacement. Understand the concepts and applications of tissue engineering. Understand natural polymers and synthetic polymer-based scaffolds.	2, 4, 5, 6	
11	nanomedicine	4	Classes	Understand and appreciate the basic concepts, preparation methods and characterization of nanobiomaterials. To understand relevant research examples.	2, 4, 5, 6	
12	Drug delivery materials	4	Classes	Understand the concepts, mechanisms and applications of controlled drug release systems. Understand biomaterials for drug delivery. Be able to design basic controlled release drug systems as required.	2, 4, 5, 6	
13	Biodiagnostics and other applications	4	Classes	Understand the classification and applications of biodiagnostic materials. Understand the applications of biomaterials in the field.	2, 4, 5, 6	
Grading	Assignments + Quizzes + Final exam					
Textbooks & Other Materials	Title	Authors	Publication	Publication date	Version	Book number
	Biomaterials Science: An Introduction to Materials in Medicine	B D (Buddy D) Ratner	Boston : Elsevier Academic Press	2013-09-01	3rd Edition	
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## Syllabus of “Advanced Integrated Circuit (IC) Fabrication and Materials”

### Course Information

Course Code	MSE5619	Credit Hours	32	Credits	2.0	
Course Name	Advanced Integrated Circuit (IC) Fabrication and Materials					
Course Type	cross-curricular					
Target Audience						
Language of Instruction	English					
School	School of Materials Science and Engineering					
Prerequisite		post				
Instructor	Wu Yunwen	Course Webpage				
Description	<p>Since the novel materials have been the main driving force for the modern integrated circuit (IC) technology development, it is important for students to gain a basic sense of science and technology in micro/nanoelectronics. This course will provide a study of basic device working mechanisms, materials, and processes for advanced IC. On the one hand, this course will introduce the basic working principles of electronic devices, introducing new materials and technologies used in advanced IC. On the other hand, combined with case study, the basic processes of current chip manufacturing are taught, and the representative technologies in advanced chip manufacturing will be taught in detail. Students are expected to gain an interdisciplinary knowledge of material science and micro-electronics.</p>					
Course objectives and contents						
Course Object	<p>By the end of this class, students are expected to achieve the goal as follows.</p> <ol style="list-style-type: none"> <li>1) Understand the working principals of modern semiconductor devices.</li> <li>2) Know the novel materials and technologies used in advanced IC.</li> <li>3) Describe the processing steps in modern semiconductor fabrication techniques.</li> <li>4) Know the processes, mechanisms and materials used in IC fabrication.</li> <li>5) Build a connection between material science and IC performance.</li> </ol>					
Class Schedule & Requirements & Course Objectives	Chapter	Key Contents	Credit Hours	Teaching methods	Homework & assessment	Objectives
	Introduction to IC	Concept of Integrated Circuits. History of IC; Moore’s Law; Know about IC industry.	2	teaching	class discussion	2
	Fundamentals of Semiconductor	Semiconductors; Charge carriers in solids; Transport of carriers; General Theory of n and p.	2	teaching	homework	1

PN junction	Basic physics for PN junction; Diode I-V characteristics; Reverse breakdown; Applications of PN junction; Fabrication of PN junction.	4	teaching	class questioning	1	
MOSFET	Structure of MOSFET Basic principles of MOSFET MOSFET IV Characteristics	4	teaching	class discussion	1	
Short channel effect	Vt roll-off; DIBL; Velocity Saturation; Hot carrier effects	4	teaching	class questioning	1	
New technologies for MOSFET	New technologies for sub-micron MOSFET, including SOI; Strained Silicon; High-k and metal gate; Multi-gate MOSFET	2	teaching	homework	1	
IC Fabrication Overview	Protocols for clean room; Processing steps in modern semiconductor fabrication: from sand to chip.	4	teaching	class discussion	2	
Interconnect	Cu interconnect; Metallization technology; Low k materials; Future interconnect.	4	teaching	class discussion	1	
Photolithography	Photolithography; Photoresist; EUV.	4	teaching	homework	1	
Final Discussion	Presentation and discussion	2	presentation	class discussion	3	
Grading	Weighting: 30% classroom performance, 40% homework, 30% major assignments					
Textbooks & Other	Title	Authors	Publication	Publication date	Version	Book
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## Syllabus of “Materials Lab 1”

### Course Information

Course Code	MSE3613	Credit Hours	64	Credits	2
Course Name	Materials Lab 1				
Course Type	Required course				
Target Audience	Undergraduate students majoring in Materials Science and Engineering				
Language of Instruction	Chinese/English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science, Materials Mechanics, and Materials Physics	post	Material Lab 2		
Instructor	Xueyan Wu	Course Webpage	<a href="https://www.icourse163.org/course/SJTU-1449795173">https://www.icourse163.org/course/SJTU-1449795173</a>		
Description	<p>"Material Lab 1" is a required course for students majoring in Materials Science and Engineering. It is a comprehensive experimental course that covers the basic methods and experimental skills training in materials science and materials processing research, as well as comprehensive research experiments on typical materials. Through a blended teaching design that combines online and offline approaches, students' awareness of experimental safety, laboratory behavior standards, and experimental skills are further enhanced. By employing integrated research-oriented experimental projects, students are able to apply various characterization techniques and analysis methods from material structure, mechanical properties, physical properties, and other aspects to dissect complex engineering problems and design solutions. This course aims to cultivate the ability to integrate and apply knowledge from multiple disciplines to analyze and solve specific experimental problems, achieving a comprehensive understanding of foundational knowledge across various fields. With a focus on cutting-edge research directions in the materials discipline, the "Materials + Innovation" experiments broaden students' international perspectives, and systematically develop their capabilities in problem analysis, problem-solving, communication, organizational management.</p>				
Course objectives and contents					
Course Object	<ol style="list-style-type: none"> <li>1. Students will be able to construct experimental systems based on experimental plans, conduct experiments safely, and collect experimental data correctly.</li> <li>2. Students will be able to analyze and interpret experimental results, and obtain reasonable and effective conclusions through information synthesis.</li> <li>3. Students will master the basic theories and methods of modern engineering tools and modern information technology tools in this major, and use them to simulate complex engineering problems and solve them.</li> <li>4. Students will be able to effectively communicate and collaborate with members from other disciplines; Ability to work independently or collaboratively within a team; Ability to organize, coordinate, and command teams to carry</li> </ol>				

	out work							
Correspondence between graduation requirement indicator points and course objectives	Objectives				Graduation Requirements Indicator Points			
	Objective 1				Graduation requirements 4.3			
	Objective 2				Graduation requirements 4.4			
	Objective 3				Graduation requirements 5.1			
	Objective 4				Graduation requirements 9.1, 9.2, 9.3			
Class Schedule & Requirements & Course Objectives)	Chapt er	Class Schedule	Objectives	Credit Hours	Teaching Style	Requireme nts	Corresponding to course objectives	
	Lab1	Safety education and scientific report writing	1. Learn laboratory rules, develop good experimental habits, and have awareness of safety precautions; 2. Writing standards for experimental reports	4	Teaching	Complete safety test		
	Lab2	Preparation of metallographic samples	1. Master the conventional methods and key points for preparing metallographic samples 2. Be familiar with the factors and metallographic characteristics that affect the quality of sample preparation	4	Blended learning and experimental operations	1. Prepare qualified metallographic samples 2 Lab report;		
	Lab3	The principle of X-ray diffractometer and sample preparation	1. Understand the basic structure and working principle of X-ray diffractometer; 2. Master the setting of phase analysis testing parameters; 3. Learn to prepare samples for X-ray diffraction phase analysis.	4	Blended learning and experimental operations	1. Prepare qualified metallographic samples 2 Lab report;		

	Lab 4	Hardness test of materials	1. Understand different hardness testing methods 2. Select appropriate testing methods based on specific materials		Blended learning and experimental operations	1. Proper operation of instruments 2. Lab report		
	Lab 5	Operation of scanning electron microscopy and observation of microstructure	1. Master the basic structure and working principle of scanning electron microscopy 2. Learn the basic operating steps	4	Blended teaching and experimental operations	1. Proper operation of instruments 2. Lab report		
	Lab 6	Preparation of Long Afterglow Luminescent Materials	1. Understand the luminescence principle of rare earth materials; 2. Master the preparation of rare earth long afterglow luminescent materials using high-temperature solid-state method; 3. Utilize multiple testing methods to analyze the structure, morphology, and properties of materials	12	Blended teaching, team work	1. Lab report 2. PPT		
	Lab 7	Injection molding and properties testing of polymers	1. Master the preparation of polymer materials through injection molding; 2. Comprehensive utilization of multiple testing methods to analyze the mechanical and thermal properties of materials	12	Blended teaching, team work	1. Lab report 2. PPT		
	Lab 8	Microstructure and properties of typical materials	1. Master the characteristics of typical material microstructure; 2. Select appropriate organizational characterization methods		Blended teaching, team work	1. Lab report 2. PPT		
	Lab 9	Simulation Lab: Measurement and analysis of ternary phase diagrams	Master the measurement and analysis of ternary phase diagrams	4	Virtual Simulation Lab	1. Test 2. Lab report		
Evaluation of the achievement	Objectives Assessment Methods			Ordinary course	Course Programs (30 points)	Final exam (50 points)	Course object	Degree of achievement of course

of course objectives		work (20 points)			ive weight	objectives
	Self-Test	10%			20%	
	Laboratory Classroom	20%			80%	
	Lab Report	50%			100%	
	Course Summary	20%			100%	
	Extra Credit	5%				
Grading	<p>Self-study and self-test before experimental class 10%</p> <p>Experimental report (complete experimental design process, truthful recording of experimental steps, authentic and credible experimental results, emphasis on result organization and analysis, score reduction for late submission) 50%</p> <p>Experimental classroom grades (on-site explanation, discussion and analysis, answering questions, experimental operations, peer teaching, work habits, safety and health) 20%</p> <p>Course summary report 20%;</p> <p>Excellent performance in various competition activities will result in an additional 1-5 points;</p> <p>The participation in safety education and website activities may increase or decrease scores by 1-5 points.</p>					
Textbooks & Other Materials	<p>陈秋龙, 周伟敏, 朱申敏. 材料综合实验教程. 化学工业出版社, 2023.9</p> <p>English reference recommended by instructors</p>					
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## Syllabus of “Materials Lab 2”

### Course Information

Course Code	MSE3614	Credit Hours	64	Credits	4
Course Name)	Materials Lab 2				
Course Type	Required course				
Target Audience	Undergraduate students majoring in Materials Science and Engineering				
Language of Instruction	Chinese/ English				
School	School of Materials Science and Engineering				
Prerequisite	Fundamentals of Materials Science, Materials Mechanics, Materials Lab	post			
Instructor	Xueyan Wu	Course Webpage	<a href="https://www.icourse163.org/course/SJTU-1449795173">https://www.icourse163.org/course/SJTU-1449795173</a>		
Description	<p>"Materials Lab 2" is a required junior subject in the School of Materials Science and Engineering at SJTU, designed to be taken after they finished Materials Lab 1. Relying on the smart laboratory, the course adopts a diversified experimental teaching model that combines virtual and physical experiments as well as online and offline approaches. This course focuses on cultivating students' 'excellent engineering practice and innovative abilities'. It utilizes a teaching model where 'teachers guide and students take the lead', integrating online and offline teaching strategies. Within the allotted course time, students will independently complete a series of project operations. This not only hones their practical skills in addressing various issues ranging from experimental safety, principles to equipment operation but also enhances their self-learning capabilities. The course is designed with two major modules: comprehensive experiments and innovative experiments. The innovative experiments consist of several meticulously crafted projects that closely align with the cutting-edge scientific achievements of the School of Materials. The course emphasizes interdisciplinary integration and innovative thinking, encouraging students to work in groups and independently select research topics. It aims to cultivate students' abilities to analyze and tackle advanced scientific and complex engineering challenges. Through this teaching approach, students can deepen their theoretical knowledge in practice and improve their overall ability to solve real-world problems.</p>				
Course objectives and contents					
Course Object	<p>1. Understand the technical standard systems, intellectual property rights, industrial policies, and laws and regulations related to the profession, and comprehend the impact of different social cultures on engineering activities; be able to analyze and evaluate the impact of professional engineering practices on society, health, safety, law, and culture, as well as the influence of these constraints on project implementation, and understand the responsibilities that should be undertaken;</p> <p>2. Be capable of constructing an experimental system based on an experimental plan, conducting experiments safely, and correctly collecting experimental data;</p>				

	<p>3.Be able to analyze and interpret experimental results, and draw reasonable and effective conclusions through information synthesis;</p> <p>4.Be capable of organizing, coordinating, and directing a team to carry out work;</p> <p>5.Participate in interdisciplinary projects; understand the natural sciences, electromechanical knowledge, management and economic knowledge, etc., involved in the project; be able to apply engineering management and economic decision-making methods in a multidisciplinary environment (including simulated environments) during the process of designing and developing solutions.</p>						
Correspondence between graduation requirement indicator points and course objectives	Objectives				Graduation Requirements Indicator Points		
	Objective 1				Graduation requirements 3.4		
	Objective 2				Graduation requirements 4.3		
	Objective 3				Graduation requirements 4.4、 6.1		
	Objective 4				Graduation requirements 9.3		
	Objective 5				Graduation requirements 11.1,11.2,11.3		
Class Schedule & Requirements & Course Objectives	Chapter	Class Schedule	Objectives	Credit Hours	Teaching Style	Requirements	Corresponding to course objectives
	Lab 1	Hydrothermal Synthesis of BaTiO <sub>3</sub> Crystals	1.Master the preparation of nanomaterials by the hydrothermal method; 2.Comprehensively utilize various testing methods to analyze the structure and morphology of the materials	12	Blended Learning, Lab Operations	Lab Reports	Objective 1, 2, 3
	Lab 2	Superelasticity and Shape Memory Effect of NiTi Alloys	1.Understand the concepts of superelasticity and shape memory effects in NiTi alloys; 2.Master the methods for testing shape memory performance; 3.Master the treatment methods for the shape memory effect	12	Blended Learning, Team Assignments, Practicum	Lab Reports	Objective 1, 2, 3

	Lab 3	The Influence of Cooling Rate on the Microstructure and Properties of Steels	1. Understand the regularities of the influence of cooling rate on the microstructure of steel; 2. Grasp the connection between material microstructure and properties	12	Blended Learning, Team Assignments, Practicum	Lab Reports	Objective 1, 2, 3		
	Lab 4	Innovative lab	Students select projects and instructors based on their interests, and independently design and implement specific projects.	24	Blended Learning, Team Assignments, Practicum	Lab reports, PowerPoint presentations	Objective 4, 5		
Evaluation of the achievement of course objectives	Assessment Methods			Objectives	Ordinary coursework (20 points)	Course Programs (30 points)	Final exam (50 points)	Course objective weight	Degree of achievement of course objectives
	Self-test			10					
	Lab Report			50					
	Laboratory classroom			20					
	Operational assessment			20					
	Extra credit			5					
Grading	<p>Self-study and self-test before the lab class (no compensation for missing) 10%</p> <p>Post-laboratory report (complete experimental design process, experimental steps recorded truthfully, experimental results are real and credible, the report focuses on the results of the collation and analysis, late submission of minus points) 50%</p> <p>Laboratory classroom performance (on-site explanation, discussion and analysis, answering questions, experimental operations, peer teaching, work habits, safety and health) 20%)</p> <p>Course summary report or operational assessment (course summary to express patriotic aspirations, responsibility, deep understanding, true feelings, the assessment operation is correct, smooth, with good experimental habits) 20%;</p> <p>Extra points 1-5 points for excellent performance in various competition activities</p> <p>Laboratory Center safety education and website activities participation in the discretionary increase or decrease in points 1-5 points</p>								
Textbooks & Other Materials	<p>陈秋龙, 周伟敏, 朱申敏. 材料综合实验教程. 化学工业出版社, 2023.9</p> <p>English reference recommended by instructors</p>								
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