能源材料化学（ME373）课程大纲

1、2022　秋季学期　(2)

2、2023　秋季学期起　(11)

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**能源材料化学** **Energy Materials Chemistry**
2.	**授课院系** **Originating Department**	机械与能源工程系 Department of Mechanical and Energy Engineering
3.	**课程编号** **Course Code**	ME373
4.	**课程学分 Credit Value**	3
5.	**课程类别** **Course Type**	专业核心课 Major Core Courses
6.	**授课学期** **Semester**	秋季 Fall （2022 秋季学期）
7.	**授课语言** **Teaching Language**	中英双语 English & Chinese
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师）** **Instructor(s), Affiliation& Contact** **(For team teaching, please list all**	曾国松，助理教授，机械与能源工程系 Email：zenggs@sustech.edu.cn Guosong Zeng, Assistant Professor, Department of Mechanical and Energy Engineering, Email：zenggs@sustech.edu.cn

	instructors)	
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	待公布 To be announced
10.	选课人数限额(可不填) Maximum Enrolment（Optional）	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	48				48

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	能源工程基础（ME304）Fundamentals of Energy Engineering
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	
14.	其它要求修读本课程的学系 Cross-listing Dept.	

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

能源材料化学是材料科学、化学、能源工程以及表面化学的一个有机结合，是系统性学习能源材料生长制备，能量材料测试与分析，材料的界面现象，表界面化学反应过程等与能源工程应用直接相关的基础知识的课程。能源材料化学具有交叉学科的突出性质，作为化学研究和新能源材料技术的一个关键领域正在世界范围内获得越来越广泛的认识重视。本课程的教学目的是使学生理解组成某种材料的原子、离子或者分子的排列组合与其宏观结构和性能之间的内在联系，不同化学反应过程在材料表面、界面处的反应过程，能源材料的制备原理，使学生学会从原子和分子水平的观点来思考和解决相关的能源材料科学问题，掌握表面化学与材料科学与工程尤其是能源工程的内在联系，了解材料科学领域在能源研究及应用方面的最新进展，以及掌握相关材料合成及测试分析方法，实现针对某技术问题开展材料设计与分析的能力培养。 为本科生奠定良好的材料化学知识基础和思维方法，为后续课程的学习服务。本课程的主要教学内容包括能源材料化学概论；晶体学与表界面热力学基础；界面工程；表界面催化过程；表界面机械力学过程；能源材料生长与改性技术；能源材料测试与分析方法；材料化学在能源领域应用等。希望通过本课程的教学能更广泛地向工程学科的学生传达本领域激动人心的研究方向以及能源材料化学为能源技术提供的机会。

Energy materials chemistry is an interdisciplinary course among materials science, chemistry, energy engineering and surface chemistry, to systematically study the energy material growth, material testing and analysis, interface phenomena, surface/interface chemical reaction process, and applications in energy field. Energy materials chemistry has a broad-based, multidisciplinary or interdisciplinary nature. As a key area of chemical research and new materials technology, it is gaining more and more recognition worldwide. The purpose of this course is to equip students with the understanding of the intrinsic link between the arrangement of atoms, ions, or molecules that make up a material and its macrostructure and properties, chemical reaction process at surface/interface, principles of energy materials growth techniques, etc., allows students to learn to apply and address related material science issues from an atomic and molecular level perspective. This course will also help students developing intrinsic links between chemistry and materials science and engineering, especially the applications in energy engineering, to understand the latest advances in applied chemistry and chemistry concepts in materials science and energy field, as well as some basic material synthesis and characterization techniques, to achieve the development of capability for material design and solution to specific problems. To lay a good material chemistry knowledge base and thinking method for undergraduate students, and to provide services for the follow-up courses. The main teaching contents of this course include the introduction of energy materials chemistry; crystallography and surface/interface thermodynamics; interface engineering; surface/interface catalysis; surface/interface mechanics; energy material growth and property modification; energy material testing and analysis; and the application of energy material chemistry in the energy field. It is hoped that the teaching of this course will more widely convey to students in the engineering disciplines the exciting research directions in this field and the opportunities that energy materials chemistry provides for new materials technologies and energy applications.

16. 预达学习成果 Learning Outcomes

1. 理解组成某种材料的原子、离子或者分子的排列组合与其宏观结构和性能之间的内在联系;
2. 应用从原子和分子水平的观点来思考和解决相关的材料科学与材料化学问题;
3. 掌握表面化学与能源材料科学与工程的内在联系;
4. 培养学生资料查阅检索能力，了解本课程所涉及的各种合成方法、结构、性能在材料研究和开发中的具体应用实例;
5. 对材料设计、制备及加工过程中的实际问题采用适当的理论进行描述和分析，从而寻求解决方案
6. 了解基本分析表征材料表面性能的仪器使用方式及适用范围;
7. 了解材料科学与表面化学领域在能源研究及应用方面的最新进展。

1. Equip students with the understanding of the intrinsic link between the arrangement of atoms, ions, or molecules that make up a material and its macrostructure and properties;
2. Allows students to learn to apply and address related material science and material chemistry issues from an atomic and molecular level perspective;
3. Develop intrinsic links between surface chemistry and energy materials science and engineering;
4. Equip the students with the capability of searching and reading literature, to better understand the material synthesis

methods, material structures, properties and performance that associated with this course;

5. Develop the capability of applying feasible theories, models and techniques to address the actual problems during the material synthesis, fabrication and processing;
6. Understand different characterization techniques for material analysis and their applicability in different areas;
7. Understand the latest advances of materials science and surface chemistry in energy engineering applications.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

第一部分：能源材料化学概论（2 学时）

- 能源材料基础
- 能源工程中的表界面科学问题
- 新能源材料设计思维与逻辑

Section 1: Energy materials chemistry outline (2 credit hours)

- Energy materials basics
- Surface chemistry in energy engineering
- Considerations in the design of new energy materials

第二部分：晶体学与表界面热力学基础（6 学时）

- 晶体与表面
- 缺陷及种类
- 晶体学理论
- 固体的表面张力与表面自由能
- 表面能与晶面取向
- 界面势垒

Section 2: Crystallography and surface/interface thermodynamics basics (6 credit hours)

- crystalline solids and surface

- Defects and category
- Crystalline states
- Surface tension and Gibbs free energy
- Surface energy and crystal orientation
- Interfacial barriers

第三部分：界面工程（8 学时）

- 固-液界面
- 固-气界面
- 固-固界面
- 界面工程与能源应用

Section 3: Interface engineering (8 credit hours)

- Solid-liquid interface
- Solid-gas interface
- Solid-solid interface
- Interface engineering and energy applications

第四部分：表界面催化过程（6 学时）

- 表界面结构与表界面反应
- 表界面电子性质
- 原子/分子与界面相互作用
- 多相催化动力学过程
- 电催化
- 光催化

Section 4: Surface/Interface catalysis (6 credit hours)

- Surface-interface structure and reaction
- Surface/interface electronic properties
- Atomic-molecular interaction at interface
- Kinetics of heterogeneous catalytic process
- Electrocatalysis
- Photocatalysis

第五部分：表界面机械过程（4 学时）

- 接触力学
- 界面摩擦学与超精密加工
- 界面中的机械化学过程

Section 5: Surface/interface mechanical process (4 credit hours)

- Contact mechanics
- Tribology and ultraprecision manufacturing
- Mechanochemistry at interface

第六部分：能源材料生长与改性（8 学时）

- 能源材料外延技术
- 晶体生长技术
- 液相沉淀法
- 固相反应
- 纳米材料
- 材料化学改性手段及能源应用

Section 6: Energy materials growth and modification (8 credit hours)

- Energy material epitaxial techniques

- Crystal materials growth techniques
- Liquid phase deposition
- Solid phase reactions
- Nanomaterials
- Materials chemical modification techniques and energy applications

第七部分：能源材料测试与分析（10 学时）

- 化学和电化学性能
- 机械力学性能
- 热电与光电性能
- 光谱分析
- 质谱分析
- 显微镜分析

Section 7: Energy materials testing and analysis (10 credit hours)

- Chemical and electrochemical testing
- Mechanical and mechanics testing
- Thermoelectric and photoelectric properties
- Spectroscopy
- Mass spectroscopy
- Microscopy

第八部分：材料在能源领域应用（4 学时）

- 可逆储氢
- 电化学储能
- 太阳能吸收与转换

- 人工光合成
- 降低能耗技术手段

Section 8: Applications of materials in energy field (4 credit hours)

- Reversible hydrogen storage
- Electrochemical energy storage
- Solar energy harvesting and conversion
- Artificial photosynthesis
- Techniques for energy saving

18. 教材及其它参考资料 Textbook and Supplementary Readings

1. Physics of Surfaces and Interfaces, Harald Ibach (Springer, 2006)
2. Surfaces and Interfaces of Solids, Hans Luth (Second Edition, Springer, 1993)
3. Physical chemistry of surfaces, Adamson, Arthur W., and Alice Petry Gast. Vol. 15. New York: Interscience publishers, 1967.
4. Surface science: an introduction, Oura, Kenjiro, et al. Springer Science & Business Media, 2013.
5. 表面与界面物理 ，恽正中，王恩信，完利祥，电子科技大学出版社，1993
6. 材料成形界面工程，吴树森，严有为，化学工业出版社 2006
7. 新能源材料-基础与应用，艾德生等，化学工业出版社
8. 新能源材料，雷永泉，天津大学出版社

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance		10		
课堂表现 Class Performance				
小测验 Quiz				

课程项目 Projects				
平时作业 Assignments		20		
期中报告 Mid-Term Test		30		
期末考试 Final Exam				
期末报告 Final Presentation		40		
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 GRADING SYSTEM

☑ A. 十三级等级制 Letter Grading
☐ B. 二级记分制（通过/不通过） Pass/Fail Grading

课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
This Course has been approved by the following person or committee of authority

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**能源材料化学** **Energy Materials Chemistry**
2.	**授课院系** **Originating Department**	机械与能源工程系 Department of Mechanical and Energy Engineering
3.	**课程编号** **Course Code**	ME373
4.	**课程学分 Credit Value**	3
5.	**课程类别** **Course Type**	专业核心课 Major Core Courses
6.	**授课学期** **Semester**	秋季 Fall （2023 秋季学期起）
7.	**授课语言** **Teaching Language**	中英双语 English & Chinese
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师）** **Instructor(s), Affiliation& Contact** **(For team teaching, please list all**	曾国松，助理教授，机械与能源工程系 Email：zenggs@sustech.edu.cn Guosong Zeng, Assistant Professor, Department of Mechanical and Energy Engineering, Email：zenggs@sustech.edu.cn

	instructors)	
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	待公布 To be announced
10.	选课人数限额(可不填) Maximum Enrolment (Optional)	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other (Please specify)	总学时 Total
学时数 Credit Hours	48				48

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	能源工程基础（ME304）Fundamentals of Energy Engineering
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	
14.	其它要求修读本课程的学系 Cross-listing Dept.	

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程的教学目的是使学生理解组成某种材料的原子、离子或者分子的排列组合与其宏观结构和性能之间的内在联系，不同化学反应过程在材料表面、界面处的反应过程，能源材料的制备原理，使学生学会从原子和分子水平的观点来思考和解决相关的能源材料科学问题，掌握表面化学与材料科学与工程尤其是能源工程的内在联系，了解材料科学领域在能源研究及应用方面的最新进展，以及掌握相关材料合成及测试分析方法，实现针对某技术问题开展材料设计与分析的能力培养。为本科生奠定良好的材料化学知识基础和思维方法，为后续课程的学习服务。希望通过本课程的教学能更广泛地向工程学科的学生传达本领域激动人心的研究方向以及能源材料化学为能源技术提供的机会。

The purpose of this course is to equip students with the understanding of the intrinsic link between the arrangement of atoms, ions, or molecules that make up a material and its macrostructure and properties, chemical reaction process at surface/interface, principles of energy materials growth techniques, etc., allows students to learn to apply and address related material science issues from an atomic and molecular level perspective. This course will also help students developing intrinsic links between chemistry and materials science and engineering, especially the applications in energy engineering, to

understand the latest advances in applied chemistry and chemistry concepts in materials science and energy field, as well as some basic material synthesis and characterization techniques, to achieve the development of capability for material design and solution to specific problems. To lay a good material chemistry knowledge base and thinking method for undergraduate students, and to provide services for the follow-up courses. It is hoped that the teaching of this course will more widely convey to students in the engineering disciplines the exciting research directions in this field and the opportunities that energy materials chemistry provides for new materials technologies and energy applications.

16. 预达学习成果 Learning Outcomes

1. 理解组成某种材料的原子、离子或者分子的结构与其宏观物理化学性能之间的内在联系;
2. 应用从原子和分子水平的观点来思考和解决相关的材料科学与材料化学问题;
3. 掌握表面化学与能源材料科学与工程的内在联系;
4. 培养学生资料查阅检索能力，了解本课程所涉及的各种合成方法、结构、性能在材料研究和开发中的具体应用实例;
5. 对材料设计、制备及加工过程中的实际问题采用适当的理论进行描述和分析，从而寻求解决方案
6. 了解基本分析表征材料表面性能的仪器使用方式及适用范围;
7. 了解材料科学与表面化学领域在能源研究及应用方面的最新进展。

1. Equip students with the understanding of the intrinsic link between the arrangement of atoms, ions, or molecules that make up a material and its macrostructure and properties;
2. Allows students to learn to apply and address related material science and material chemistry issues from an atomic and molecular level perspective;
3. Develop intrinsic links between surface chemistry and energy materials science and engineering;
4. Equip the students with the capability of searching and reading literature, to better understand the material synthesis methods, material structures, properties and performance that associated with this course;
5. Develop the capability of applying feasible theories, models and techniques to address the actual problems during the material synthesis, fabrication and processing;
6. Understand different characterization techniques for material analysis and their applicability in different areas;
7. Understand the latest advances of materials science and surface chemistry in energy engineering applications.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

第一部分：固体物理学基础（12 学时）

- 晶体结构
- 晶体衍射与倒格子
- 轨道理论
- 能带理论
- 教学成果检测

Section 1: Solid state basics (12 credit hours)

- Crystal structure
- Wave diffraction and the reciprocal lattice
- Orbital theory
- Band theory
- Quiz

第二部分：材料分类（12 学时）

- 金属材料
- 半导体材料与无机非金属陶瓷材料
- 有机高分子材料
- 复合材料
- 新型纳米材料

Section 2: Material category (12 credit hours)

- Metal
- Semiconductors and inorganic ceramics
- Polymers
- Compounds

- Novel nanomaterials

第三部分：能源材料生长与改性（8 学时）

- 单晶材料生长与化学合成技术
- 能源薄膜材料外延与化学合成技术
- 非晶材料生长制备
- 表面化学改性手段
- 教学成果检测

Section 3: Energy materials growth and modification (8 credit hours)

- Single crystal materials growth techniques
- Energy thin film material epitaxial techniques
- Liquid phase deposition
- Amorphous phase synthesis
- Materials chemical modification techniques
- Quiz

第四部分：材料合成与性能展示课（4 学时）

- 磁控溅射
- 化学气相沉积
- 电化学沉积
- 电化学测试
- 机械性能测试
- （该部分为实验室教授，通过观摩设备仪器，展示不同材料生长与分析性能的技术与方法）

Section 4: Material synthesis and properties (4 credit hours)

- PVD

- CVD
- Electrochemical deposition
- Electrochemical testing
- Mechanical properties characterization
- (This part is the in-lab course, providing the students with the opportunity to watch and learn the whole real process of material growth and characterization)

第五部分：表界面催化（8 学时）

- 表面和界面
- 光催化
- 电催化
- 机械催化及其它

Section 5: Surface/Interface catalysis (8 credit hours)

- Surface and Interface
- Photocatalysis
- Electrocatalysis
- Mechanocatalysis and others
-

第六部分：材料在能源领域应用（4 学时）

- 可逆储氢
- 电化学储能
- 太阳能吸收与转换
- 人工光合成
- 降低能耗技术手段

Section 6: Applications of materials in energy field (4 credit hours)

- Reversible hydrogen storage
- Electrochemical energy storage
- Solar energy harvesting and conversion
- Artificial photosynthesis
- Techniques for energy saving

18. 教材及其它参考资料 Textbook and Supplementary Readings

1. Introduction to solid state physics, 8th edition, Charles Kittel (John Wiley, 2004)
2. Materials Chemistry, Bradley D. Fahlman (Springer, 2018)
3. Physics of Surfaces and Interfaces, Harald Ibach (Springer, 2006)
4. Surfaces and Interfaces of Solids, Hans Luth (Second Edition, Springer, 1993)
5. Physical chemistry of surfaces, Adamson, Arthur W., and Alice Petry Gast. Vol. 15. New York: Interscience publishers, 1967.
6. Surface science: an introduction, Oura, Kenjiro, et al. Springer Science & Business Media, 2013.
7. 曾兆华，杨建文，化学工业出版社出版的高等学校教材:材料化学(第 2 版)
8. 表面与界面物理 ，恽正中，王恩信，完利祥，电子科技大学出版社，1993
9. 材料成形界面工程，吴树森，严有为，化学工业出版社 2006
10. 新能源材料-基础与应用，艾德生等，化学工业出版社
11. 新能源材料，雷永泉，天津大学出版社

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance		10		
课堂表现				

Class Performance				
小测验 Quiz		30		
课程项目 Projects				
平时作业 Assignments		20		
期中报告 Mid-Term Test				
期末考试 Final Exam		40		
期末报告 Final Presentation				
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 GRADING SYSTEM

☑ A. 十三级等级制 Letter Grading
☐ B. 二级记分制（通过/不通过） Pass/Fail Grading

课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
This Course has been approved by the following person or committee of authority