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**	表界面科学与分析技术 Surface and Interface Science and Analysis
2.	**授课院系 Originating Department**	机械与能源工程 Department of Mechanical and Energy Engineering
3.	**课程编号 Course Code**	ME362
4.	**课程学分 Credit Value**	3
5.	**课程类别 Course Type**	专业选修课 Major Elective Courses
6.	**授课学期 Semester**	春季 Spring
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 instructors）**	王帅, 机械与能源工程 Shuai Wang, Department of Mechanical and Energy Engineering, wangs@sustech.edu.cn
9.	**实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact**	曾志，机械与能源工程 Zhi Zeng, Department of Mechanical and Energy Engineering, 11849227@mail.sustech.edu.cn
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	46	2			48

12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	PHY105B 大学物理 (下) B General Physics II B CH101B 化学原理 B General Chemistry B
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

表面与界面科学是一门独立的、广博精深的、融合材料、机械、冶金、电子、物理、化学的交叉学科。学习表界面相关知识对从事与结构材料设计、薄膜材料、半导体工程、微纳器件、精密加工以及增材制造等方向的研究工作都具有重要意义。该课程主要目标是通过对表界面物理化学原理的学习，使学生对与表界面相关的热力学分析、扩散原理、缺陷等知识有较为深入的理解，并提高运用理论解决应用问题的能力；通过重点掌握扫描电镜显微学、透射电镜显微学、原子力显微学等表征手段的基本原理，增强学生表界面微观结构研究方法的认识，提升在相关科研和工作领域的分析能力；通过对表界面加工和调控技术的学习了解相关技术的发展方向和前沿热点。

Surface and interface science is an independent, widely applied, and interdisciplinary course, including materials, mechanics, metallurgy, electronics, physics and chemistry. It is critical for students planned to work in area of design of structural materials, thin films, semiconductor, micro- and nano- devices, precision machining, and additive manufacturing. The main objective of this course is to introduce the physics and chemistry theory of surface and interface, and enhance the student's ability of understanding and using thermodynamic analysis, diffusion mechanism, defects theory to solve engineering problem. By acquainting student with the basic theory and characterization methods in scanning electron microscopy, transmission electron microscopy, and atomic force microscopy, improve their understanding of microstructure in different scales, and promote their researching and working ability in the related field. Another important objective of is to acquaint student with the cutting edge surface processing and interface controlling technologies in the field.

16. 预达学习成果 Learning Outcomes

该课程主要目的是向机械工程、材料科学与工程、应用物理、化学、航空航天工程、微电子科学与工程的学生介绍表面与界面的基础物理化学理论、应用及分析技术。通过学习，学生应可以：

1. 熟知米勒指数和基本晶体学。根据给定低指数表面的原子结构，计算简单表面的表面能。熟知表界面短程和长程有序的区别。了解 γ-surface 的概念，认识能量与原子排列几何的关系。

2. 认识固体中缺陷的种类及其重要性。熟知界面的分类，了解固体界面的取向错配角、点缺陷、原子的共格与非共格关系对固体性能的影响。

3. 描述表面吸附与界面偏析的基础模型和动力学过程，理解背后的物理含义。了解表面催化的基础反应过程。描述表面扩散与界面扩散的机理及主要控制参数。

4. 描述机械工程、半导体工业、航空、光学、能源工程领域重要的镀膜技术，理解其物理化学过程。

5. 理解重要的分析表界面微观组织、原子结构、三维形貌、粗糙度、化学成分的表征手段的基本原理。描述扫描电镜、透射电镜观察显像和分析取向关系的原理，认识在表界面的电镜测试中衬度、分辨率、景深等的含义，熟知电镜研究的优越性和局限性。

6. 了解表界面对电子传输过程的影响，认识调控表界面粗糙度、亚表面缺陷在半导体工业中的应用。

7. 描述晶界、析出物-基体相界与固体力学性能的关系。认识晶界工程学的概念，熟悉其在新材料研发中的应用。

The objective of this course is to acquaint students in Mechanical Engineering, Materials Science and Engineering, Applied Physics, Chemistry, Aerospace Engineering, and Microelectronics Science and Engineering with fundamental theory, application and analysis methods in the field of surface and interface science. After the course the student should be able to:

1. Know Miller index and basics of Crystallography. Calculate the surface energy of a given surface with simple index. Understand the concept of γ-surface and the connection between energy and atomic arrangement.

2. Describe different kinds of defects in solid and their importance in science and engineering. Know different types of interface, and give the physical meaning of the misorientation, point defects, and coherent/incoherent relation in interface.

3. Describe the basic kinetic models for absorption and segregation in surface and interface, understand the underlying mechanism. Know fundamental catalytic reactions and related simple kinetic models. Describe the diffusion process and governing parameters of surface and interface.

4. Describe the important methods to grow thin films in mechanical engineering, semiconductor, aerospace, optical industry, and energy engineering. Understand the physics and chemistry in thin film technology.

5. Know the fundamental methods for characterizing microstructure, atomic configuration, roughness, 3D tomography, and composition distribution of surface and interface. Describe the theory of imaging and orientation investigation in electron microscope. Understand the meaning of contrast, resolution, depth of field in microscope. Know the cons and pros of scanning electron microscope and transmission electron microscope.

6. Know the influence of interface and surface structures on the electron transfer. Understand the importance of controlling surface roughness and defect in semiconductor industry.

Describe the relation between interface, such as grain boundary and precipitate-matrix interface, and mechanical properties of solids. Understand the concept of grain boundary engineering and its application in design of new materials.

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.)

Section 1	概论和表界面物理化学基础 (2 Credit hours) Introductions and basics for surface and interface science - Historical sketch - Definition and importance - Physics and chemistry in surface and interface - Applications
Section 2	表界面晶体学基础：固体中的不完美 (4 Credit hours) Basics of surface and interface Crystallography: Imperfections in solids - Crystal system and crystallographic directions of surface and interface - Elasticity and Anisotropy - Point defects - Dislocations-linear defects - Defects in surface and interface and its importance
Section 3	表界面的形成和原子结构 (3 Credit hours) Formation of surface and interface and the atomic structure - The making of crystals - Surface energy/tension and relation to atomic arrangement - Structural models for solid-solid interfaces - Special interface: grain boundaries
Section 4	表界面热力学原理 (3 Credit hours) Thermodynamics of surface and interface - General concepts: internal energy and free energy - Energy and entropy: the driving force - Case study: introduction to solidification thermodynamics - Gibbs isotherm, surfactant, defectant, - Metastable equilibrium between surface and interface
Section 5	吸附与偏析 (3 Credit hours) Adsorption and segregation - Physisorption and chemisorption - Adsorption energy and governing process - Segregation and its influence on materials property - Adsorption and segregation in microscale
Section 6	表界面动力学：热振动和扩散 (3 Credit hours) Dynamics in surface and interface: vibration and diffusion - General aspects of phonons - Surface lattice dynamics - Diffusion mechanisms - Key factors in diffusion process - Surface diffusion - Interfacial diffusion
Section 7	表界面表征分析: 目的、原理 (3 Credit hours) Characterization and analysis methods: objective and theory - Objective for surface and interface observation - Optical microscopy and the limitation - Resolution, contrast, depth of field - Distortion in optics

Section 8	表界面表征分析: 电子显微镜和能谱 (4 Credit hours) Characterization and analysis methods: electron microscope and energy spectrum - Schematic Diagram for scanning electron microscope - Good image and how to obtain it - Schematic Diagram for transmission electron microscope - Key methods in TEM - Introduction to scanning transmission electron microscopy - EDS: chemical composition analysis in electron microscope
Section 9	表界面表征分析: 离子束和其他分析测试方法 (3 Credit hours) Characterization and analysis methods: ion beam and other methods - Image with ion: secondary ion mass spectrometry - Dig and see: Focused ion beam machining - Touch and see: Scanning tunnelling microscopy and Atomic force microscopy - Auger electron spectroscopy and other important methods
Section 10	课堂专题演讲 (2 Credit hours) Class presentation and discussion
Section 11	表面改性与薄膜技术 (3 Credit hours) Surface modification and thin films - Surface modification: how to strengthen materials - Surface modification: gain special functions - Grow films: PVD and CVD - Grow films: Epitaxy - Surface reaction controlled process: Atomic layer deposition
Section 12	表界面的模拟计算方法 (3 Credit hours) Calculation methods in surface and interface science - Introduction to molecular dynamics and optimization of atomic strucutre - Introduction to the first principle calculation and its application on surface and interface research - Hybrid methods: QMMM
Section 13	表面微细加工 (3 Credit hours) Surface micromachining - Light, Plasma, Laser, Electron: weapons for machining and their limitations - Cutting in microscale - Polishing in microscale - Making nano features on surface
Section 14	表界面的电性能 (3 Credit hours) Electron properties at surface and interfaces - General principles for electronic structure - Defects in semiconductor - Metal-semiconductor interface - Some applications of metal-semiconductor interface

Section 15	晶界和晶界工程学 (3 Credit hours) Grain boundary engineering - Coincidence site lattice - Grain boundary energy and mechanics - Electron transfer and thermal transport in grain boundaries - Grain boundary engineering: the art of controlling grain boundary type
Section 16	界面失效 (3 Credit hours) Interfacial failure - Mechanical behaviour of materials - Importance of interface for mechanical properties - Chemomechanics: interplay between chemical reaction and mechanical process at interface and surface
Note	Lectures slots could be swapped around

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

教材：“Physics of Surfaces and Interfaces” Harald Ibach (Springer, 2006)

其他参考：“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）“Surfaces and Interfaces of Solids”, Hans Luth (Second Edition, Springer, 1993) “Physics at Surfaces”, Andrew Zangwill (Cambridge U. Press, 1988) “Fundamentals of Surface and Thin Film Analysis”, L.C. Feldman and J.W. Mayer, (Elsevier, N.Y. 1986)

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		5		
课堂表现 Class Performance		5		
小测验 Quiz		10		
课程项目 Projects		20		
平时作业 Assignments		20		
期中考试 Mid-Term Test				
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