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	**等离子体原理与应用** **Fundamentals and applications of plasma**
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	ME452
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 / 夏季 Summer / 秋季 Fall
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）	邓辉/助理教授 机械与能源工程系 Hui DENG / Assistant professor Department of Mechanical and Energy Engineering Email: dengh@sustech.edu.cn
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	ME302 机械制造基础 Fundamentals of Manufacturing
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

等离子体是物质的第四态，它在人们的生活以及生产过程中扮演着非常重要的角色。在精密制造领域，等离子体已经发展成为一种非常重要的技术手段。作为一门交叉学科，等离子体涉及到物理、化学、表面科学以及工程应用等诸多内容。

本课程的教学目标是使学生掌握等离子体放电的基本原理并对等离子体的相关应用有清晰的了解。本课程的第一部分将从物理的角度对等离子体放电过程进行分析；第二部分将阐述等离子体的化学动力学过程；第三部分介绍各种等离子体的激发过程及特性；第四部分会对等离子体的典型应用进行介绍。

As the fourth state of mater, plasma plays an very important role in our daily life as well as industry production. Especially in precision manufacturing, plasma has become an useful approach. To understand the principles and applications of plasma, theoretical knowledge, such as plasma physics, chemical kinetics, surface science and engineering is indispensable.

The objective of this course is to give an overall introduction to the principles of plasma discharge and offer the students with the knowledge of plasma applications. In the first part, the physical fundamentals about plasma discharge will be introduced. In the second part, chemical kinetics of plasma will be introduced. In the third part, the properties of various plasma sources will be introduced. Finally, some typical applications of plasma will be discussed. The students will be cultivated with the ability to understand the principles and applications of plasma and conduct related researches.

16. 预达学习成果 Learning Outcomes

通过本课程的学习，可以期待以下的学习成果。
1. 掌握等离子体放电的原理，包括其物理和化学内涵；
2. 对等离子体的典型应用有充分了解，包括原理、优势以及局限性；

By the end of this course, students should have mastered the following abilities:
1. Understand the physical and chemical principles of plasma;
2. Be familiar with the typical applications of plasma and be able to analyse their advantages and disadvantages.

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.)

课程内容	教学要求	学时分配
1. 课程介绍 • 等离子体的定义和分类； • 等离子体的基本性质和应用； • 本课程的性质、任务和主要内容； 1. Introduction • Definition and classification of plasma; • Basic properties and applications of plasma;	了解等离子体的基本性质，并对其在日常生活和工业生产中的应用有大致了解；了解本课程的教学内容和评价方法。 Understand the basic properties of plasma, and have a general understanding of its application in	2

• The nature, tasks and main content of the course;	daily life and industrial production; understand the teaching content and evaluation methods of this course.	
2. 气体放电的基本物理过程 • 等离子体中的粒子； • 粒子碰撞过程中的能量转移； 2. The basic physical process of gas discharge • Particles in the plasma; • Energy transfer during particle collisions;	了解气体放电的基本物理过程，包括等离子体中有哪些粒子，他们是如何产生的，以及他们的碰撞行为。 Understand the basic physical processes of gas discharge, including which particles are in the plasma, how they are produced, and their collision behavior.	4
3. 汤生放电 • 汤生放电理论； • α 与 β 放电过程； • 汤生放电的局限性； 3. Townsend discharge • The theory of Townsend discharge; • α and β discharge processes; • The limitation of Townsend theory;	掌握汤生放电理论。 Understand the Townsend discharge theory.	4
4. 帕刑定律 • 帕刑法则的提出过程； • 各因素的帕刑放电过程的影响； 4. Paschen's law • The proposal of Paschen's law; • Factors affecting the discharge potential;	了解帕刑法则的提出过程，并掌握该法则在具体放电案例中的应用。 Understand the process of proposing the Paschen's law and master the application of the law in specific discharge cases.	2
5. 等离子体的宏观性质 • 等离子体的电中性与德拜屏蔽； • 等离子体振荡； • 离子流动和密度分布； • 等离子体鞘层； 5. Macroscopic properties of plasma • Electrical neutrality of the plasma; • Debye shielding; • Plasma oscillation; • Ion flow and density distribution; • Plasma sheath;	了解等离子体的宏观性质，掌握德拜屏蔽、等离子体振荡与鞘层的发生机理。 Understand the macroscopic properties of plasma, master the mechanism of Debye shielding, plasma oscillation and sheath.	4
6. 直流放电 • 各种直流放电模式； • 辉光放电与低温等离子体； • 弧光放电与热等离子体； 6. Direct current discharge • Various DC discharge modes; • Glow discharge and low temperature plasma; • Arc discharge and thermal plasma;	对各种形式的直流放电的性质有所了解。 Know the nature of various forms of DC discharge.	2
7. 射频与微波等离子体 • 等离子体生成与天线耦合； • 电容耦合等离子体； • 电感耦合等离子体； 7. RF and microwave plasma	掌握 CCP 与 ICP 的基本性质。 Understand the fundamentals of CCP and ICP.	4

• Plasma generation coupled to the antenna; • Capacitively coupled plasma; • Inductively coupled plasma;		
8. 等离子体辅助抛光 • 抛光加工简介； • 等离子体辅助抛光的基本原理； • 等离子体辅助抛光单晶碳化硅； • 等离子体辅助抛光单晶氮化镓； 8. Plasma assisted polishing • Fundamentals of polishing; • Principles of plasma assisted polishing; • Application of PAP to 4H-SiC; • Application of PAP to GaN;	掌握等离子体辅助抛光的基本原理，并对其在难加工材料的抛光领域的应用有所了解。 Master the basic principles of plasma-assisted polishing and understand its application in the polishing of difficult-to-machine materials.	4
9. 等离子体加工 • 等离子体化学气化加工； • 等离子体射流成形加工； • 等离子体加工多相材料； • 其他的等离子体加工技术； 9. Plasma assisted machining • Plasma chemical vaporization machining; • Plasma jet figuring; • Plasma machining of multiphase materials; • Other plasma-based machining techniques;	了解国内外在等离子体加工领域的最新进展，掌握各种等离子体加工技术的基本原理。 Understand the latest developments in plasma processing at home and abroad, and master the basic principles of various plasma processing technologies.	4
10. 等离子体表面改性 • 等离子体粘合的最新进展； • 含氟树脂的基本性质； • 等离子体粘合技术的原理； • 应用展望； 10. Plasma assisted surface modification • Recent advances in plasma bonding; • The basic properties of fluorine resins; • The principle of plasma bonding technology; • Application outlook;	掌握等离子体表面改性的基本原理和应用。 Understand the mechanisms of plasma surface modification and its applications.	2
11. 等离子体沉积 • 等离子体物理气相沉积 • 等离子体化学气相沉积 11. Plasma deposition • Physical vapor deposition; • Chemical vapor deposition;	掌握基于等离子体的物理气相沉积和化学气相沉积技术。 Understand the plasma-based PVD and CVD technologies.	2
12. 等离子体刻蚀 • 刻蚀要求和工艺过程； • 刻蚀反应动力学； • 一些刻蚀体系； • 衬底上的电荷积累； 12. Plasma etching • Etching requirements and processes; • Etching reaction kinetics; • Some etching systems; • Charge accumulation on the substrate;	学习等离子体刻蚀的原理，掌握常见的等离子体刻蚀工艺，能够就具体的刻蚀案例进行分析。 Learn the principle of plasma etching, master the common plasma etching process, and analyse the specific etching cases.	4
13. 微波等离子体生长金刚石 • 金刚石的基本性质； • 单晶金刚石的各种生长工艺；	掌握微波等离子体生长金刚石技术的原理和工艺。 Understand the mechanism and	2

• 微波等离子体生长金刚石技术； 13. Growth of single crystal diamond using microwave plasma • The basic properties of diamonds; • Various growth processes for single crystal diamonds; • Microwave plasma growth diamond technology;	process of microwave plasma-based synthesis of single crystal diamond.	
14. 等离子体灭菌 • 灭菌的基本要求和常见工艺； • 等离子体灭菌的基本原理； • 一种纸基等离子体灭菌器的介绍； 14. Plasma sterilization • Basic requirements for sterilization and common processes; • The basic principle of plasma sterilization; • Introduction to a paper-based plasma sterilizer;	学习等离子体灭菌技术，掌握其基本原理，了解常见的等离子体灭菌器的设计。 Learn plasma sterilization technology, master its basic principles, and understand the design of common plasma sterilizers.	2
15. 等离子体诊断 • 等离子体诊断的要求； • 各种等离子体诊断技术； • OES 光谱诊断的原理和应用； 15. Plasma diagnostics • Requirements for plasma diagnostics; • Various plasma diagnostic techniques; • Principles and applications of OES spectral diagnosis;	了解等离子体诊断的基本原理和应用。 Understand the mechanisms and applications of plasma diagnostic techniques.	2
16. 等离子体仿真 • 等离子体仿真的基本要求； • 基于 COMSOL 的等离子体流场和电磁场仿真； • 基于 LAMMPS 的等离子体分子动力学仿真； • 基于密度泛函理论(DFT)的等离子体第一性原理计算； 16. Plasma simulation • Basic requirements for plasma simulation; • COMSOL-based plasma flow field and electromagnetic field simulation; • Plasma molecular dynamics simulation based on LAMMPS; • Plasma first-principles calculation based on density functional theory (DFT);	了解等离子体仿真的基本要求，能够从不同的尺度对一些常见放电体系进行仿真计算。 Understand the basic requirements of plasma simulation, and be able to simulate some common discharge systems from different scales.	4

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

教材：Principles of Plasma Discharges and Materials Processing, Michael A. Lieberman, Alan J. Lichtenberg, John Wiley & Sons, 8 Apr 2005

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		20		
小测验 Quiz				
课程项目 Projects				
平时作业 Assignments				
期中考试 Mid-Term Test				
期末考试 Final Exam				
期末报告 Final Presentation		70		
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

机械与能源工程系教学委员会