东北大学秦皇岛分校本科课程教学大纲

一、课程基本信息

<table>
<tr><td>开课单位</td><td colspan="3">计算机与通信工程学院</td><td>课程代码</td><td colspan="5">3100112019</td></tr>
<tr><td>中文名称</td><td colspan="8">电子元件与制造</td></tr>
<tr><td>英文名称</td><td colspan="8">Electronic Components and Fabrication</td></tr>
<tr><td>总学时</td><td>56</td><td rowspan="2">理论学时</td><td rowspan="2">28</td><td rowspan="2">实验学时</td><td rowspan="2">28</td><td rowspan="2">上机学时</td><td rowspan="2"></td><td rowspan="2">设计学时</td><td rowspan="2"></td><td rowspan="2">课外学时</td><td rowspan="2"></td></tr>
<tr><td>学　分</td><td>3.5</td></tr>
<tr><td>课程类型</td><td colspan="8">☑理论课程　☑理论（含实验）课程　☐实践类课程</td></tr>
<tr><td>课程类别</td><td colspan="8">☐通识类　☑学科基础类　☐专业方向类　☐实践类</td></tr>
<tr><td>适用专业</td><td colspan="8">通信工程 CE</td></tr>
<tr><td>先修课程</td><td colspan="8">集成电路系统设计、数字电子技术基础</td></tr>
<tr><td>建议开课学期</td><td colspan="8">☐1-1 ☐1-2 ☐2-1 ☑2-2 ☐3-1 ☐3-2
☐4-1 ☐4-2 ☐5-1 ☐5-2 ☐*（代表每学期都开设）</td></tr>
<tr><td>考核方式</td><td colspan="4">☐考试 ☑考查</td><td>成绩分制</td><td colspan="3">☑百分制 ☐五级制
☐二级制</td></tr>
<tr><td>使用教材</td><td colspan="8">无</td></tr>
<tr><td>参考书及教学资源</td><td colspan="8">Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition By Marc J Madou, Taylor and Francis，2001.</td></tr>
<tr><td>其他说明</td><td colspan="8">无</td></tr>
</table>

二、课程简介

中文描述

本课程涵盖物联网(IoT)节点组件级的硬件技术，特别关注微型化和纳米技术提供的可能性。能够打开“组件箱”，熟悉当前的小型化技术及其功能和局限性，是有意义的物联网系统设计的关键要求，也是预测下一个技术进步以开启突破性创新的关键要求。学生学习微型化系统所需的各种电子和光子组件。他们能够基本掌握半导体物理和技术，小型化逻辑、通信和传感器件的工作原理，它们的性能窗口/规格，以及它们是如何制作和使用的打包。学生还能够辨别性能、质量和可靠性的概念，总的来说，他们能够选择一类组件和电子/光子方法来构建一个小型化系统，以解决给定的现实中的问题。

English Description

This subject covers hardware technologies in Internet of Things (IoT) nodes at the component level, with particular focus on the possibilities offered by miniaturisation and nanotechnology.Being able to open the 'component boxes' and become familiar with current miniaturised technologies and their capabilities and limitations is a crucial requirement for meaningful design of an IoT system and for anticipating the next technological advances to unlock radical innovation. Students learn about the diverse electronic and photonic components required in a miniaturised system. They achieve a basic command of semiconductor physics and technologies, the working principles of miniaturised logic, communication and sensing devices, their performance windows/specifications and how they are fabricated and Packaged. Students are also able to discern the concepts of performance, quality and reliability, and overall, they are able to select a class of components and electronic/photonic approaches to build a miniaturised system for a solving a given real life problem.

三、课程目标

1、知识目标：

1-1：描述掺杂、结、二极管和晶体管，以及它们在半导体技术中的制造过程

1-2：研究传感、转导的广泛原理，以及传感器如何在电子学和光子学中实现和制造

1-3：解构微结构:制造，包装和测试，对电子产品进行失效分析

2、能力目标：

2-1：为一个组件和一个小系统建模，并确定电子性能上下文中的模型限制。

2-2：确定所需组件的方法、类型和规格

3、德育/素养目标：

3-1：具有正确的价值观和社会责任感，培养优秀的职业道德和行为规范。获得良好的口头和书面沟通能力，团队协作意识和人际交往能力。

3-2: 提高学生的创新意识，不怕困难和有效解决实际问题的能力。

3-3: 拥有良好的跨文化和领域的沟通能力，培养能对专业领域的任务进行合理的规划，分解任务并按时、高效率和高质量完成的能力。

表 1 课程目标与毕业要求的对应关系

毕业要求	指标点	课程目标	关联性（H/M/L）
2、问题分析：能够应用数学、自然科学和工程科学的基本原理、方法和手段，识别、表达、并通过文献研究分析复杂工程问题，以获得有效结论。	指标点 2-1：能够应用数学、自然科学和工程科学的基本原理、方法和手段，分析、识别、表达本专业相关的复杂工程问题。	1-1，1-2，1-3,2-1,2-2，, 3-2,	H
	指标点 2-2：能够应用数学、自然科学和工程科学的基本原理、方法和手段，针对实际复杂工程问题设计针对性的技术方案，并综合运用文献、科学理论和技术手段予以解决。	1-1，1-2，1-3，2-1,2-2	M
3、设计/开发解决方案:能够设计针对复杂工程问题的解决方案，设计满足特定需求的系统、 单元或流程，并能够在设计环节中体现创新意识，考虑社会、健康、安全、法律、文化以及环境 等因素。	指标点 3-1:能够设计针对本专业相关复杂工程问题的解决方案，能够设计和开发实现特定功 能、满足特定需求的信息传输、信号处理或网络通信系统。	1-3,2-1,2-2，3-1,3-2,3-3	H
4、研究:能够基于科学原理并采用科学方法对复杂工程问题进行研究，包括设计实验、分析 与解释数据、并通过信息综合得到合理有效的结论。	指标点 4-1：能够基于科学原理并采用科学方法，在本专业相关理论指导下对复杂工程问题设计实验进行研究。	1-1，1-2，1-3，2-1,2-2	M
5、使用现代工具：能够针对复杂工程问题，开发、选择与使用恰当的技术、资源、现代工程工具和信息技术工具，包括对复杂工程问题的预测与模拟，并能够理解其局限性。	指标点 5-1：能够对本专业相关复杂工程问题进行建模与分析，理解获取相关信息参数的必要性与基本方法，并理解其局限性。	1-1，1-2，1-3，2-1，2-2 3-1,3-2,3-3	H

四、主要教学内容

（一）理论教学

第 1 章 Introduction （支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1）Moore's Law of nanotechnology.

（2）CMOS transistor principle.

（3）Miniaturized devices and systems.

【2】学习目标：

了解:Course overview and its requirements.

理解:Moore's Law of nanotechnology.

掌握:CMOS transistor miniaturization device and system.

【3】重点内容：

（1）Moore's Law of nanotechnology.

（2）CMOS transistor principle.

（3）Miniaturized devices and systems.

【4】难点内容：

（1）CMOS transistor principle.

（2）Miniaturized devices and systems.

【5】思政案例：

Study of nanochip technology and semiconductor process methods deeply to solve the technical problems of "stuck neck" by foreign countries.

第 2 章： Semiconductor theory （支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1）Transistors.

（2）Semiconductors.

（3）Intrinsic semiconductor.

（4）Basic concepts and connotations of bandgap and Fermi levels.

【2】学习目标：

了解：Transistor, semiconductor, intrinsic semiconductor.

理解：The basic concept and connotation of band gap and Fermi level.

掌握：Principle of diode, basic principle of rectification p-n junction.

【3】重点内容：

Principle of diode.

Basic principle of rectification p-n junction.

【4】难点内容：

Basic concept and connotation of band gap.

The basic concept and connotation of Fermi level.

【5】思政案例：

Learning the practical theoretical basis of semiconductor physics is conducive to the development of innovative capabilities and is useful for China’s innovative research in scientific.

第 3 章： MOS devices and manufacturing （支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1） Intermediate band, semiconductor p-n junction.

（2）MOS field effect transistor and CMOS technology.

【2】学习目标：

了解：Intermediate bandgap semiconductor p-n junction.

理解：MOS FET CMOS technology.

掌握：The application of MOSFET in a NAND gate silicon logic Technologies

【3】重点内容：

MOS FET CMOS technology.

【4】难点内容：

The application of MOSFET in a NAND gate silicon logic.

第 4 章：Optoelectronics and LEDs（支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1）Emission spectrum of an LED (Light emitting diodes)

（2）Methods of injection Semiconductor lasers GaAsP LEDs

【2】学习目标：

了解：Emission spectrum of an LED.

理解：Methods of injection Semiconductor lasers GaAsP LEDs.

掌握：The principle of emission spectrum of an LED.

【3】重点内容：

Methods of injection Semiconductor lasers GaAsP LEDs.

【4】难点内容：

The principle of emission spectrum of an LED.

第 5 章：Introduction to MEMS（支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1）MEMS type transducers.

（2）main parameters of sensor

【2】学习目标：

了解：MEMS type transducers.

理解：Examples of MEMS sensor system.

掌握：Sensor performance indicators.

【3】重点内容：

Examples of MEMS sensor system.

【4】难点内容：

Sensor performance indicators.

第 6 章： Advanced electronic devices （支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

Advanced electronic devices

【2】学习目标：

了解：Basic concepts of advanced electronic equipment.

理解：Basic principles of advanced electronic devices.

掌握：Basic connotation of advanced electronic equipment.

【3】重点内容：

The principles of advanced electronic devices.

【4】难点内容：

The connotation of advanced electronic equipment.

第 7 章： MEMS and Electronic Systems （支撑教学目标 1-3,2-1,2-2,2-3,3-1,3-2,3-3）

【1】知识点：

（1）MEMS actuation mechanisms.

（2）The digital micro-mirror device and other MEMS examples

【2】学习目标：

了解：MEMS examples.

理解：The digital micro-mirror device.

掌握：MEMS actuation mechanisms.

【3】重点内容：

MEMS actuation mechanisms.

【4】难点内容：

The digital micro-mirror device, MEMS examples

第 8 章：Packaging and Reliability （支撑教学目标 1-1,1-2,1-3,2-1,2-2,2-3,3-1,3-2）

【1】知识点：

（1）Electronic packaging,packaging steps,chip capping and bonding methods.

（2）Reliability concepts,accelerated Reliability test standards, agreed worldwide.

【2】学习目标：

了解：Accelerated reliability worldwide agreed standards test.

理解：chip capping and bonding methods.

掌握：Electronic packaging,packaging steps,chip capping and bonding methods.

【3】重点内容：

Electronic packaging,packaging steps,chip capping and bonding methods.

【4】难点内容：

Chip cover bonding method Steps.

第 9 章：Software Defined Radios （支撑教学目标 1-3,2-1,2-2,2-3,3-1,3-2,3-3）

【1】知识点：

（1）The basic concepts of Software defines microwave.

（2）The basic principles of Software defines microwave.

（3）The basic connotation of Software defines microwave.

【2】学习目标：

了解：The basic concepts of Software defines microwave.

理解：The basic connotation of Software defines microwave.

掌握：The basic principles of Software defines microwave.

【3】重点内容：

The basic concepts and principle of Software defines microwave.

【4】难点内容：

The basic principles of Software defines microwave.

【5】思政案例：

Learn foreign advanced technology and work hard for the rise of China.

第 10 章：Introduction to Laser （支撑教学目标 1-3,2-1,2-2,2-3,3-1,3-2,3-3）

【1】知识点：

（1）The basic concepts of laser.

（2）The basic principles of laser.

（3）The basic connotation of laser.

【2】学习目标：

了解：The basic concepts of laser.

理解：The basic connotation of Software defines microwave.

掌握：The basic principles of Software defines microwave.

【3】重点内容：

The basic concepts and principle of laser.

【4】难点内容：

The basic principles of laser.

第 11 章：3D Printed Electronic Devices for 5G and Space Applications（支撑教学目标 1-3,2-1,2-2,2-3,3-1,3-2,3-3）

【1】知识点：

（1）The basic concepts in 3D Printed Electronic Devices for 5G and Space Applications.

（2）The basic principles in 3D Printed Electronic Devices for 5G and Space Applications.

（3）The basic connotation in 3D Printed Electronic Devices for 5G and Space Applications.

【2】学习目标：

了解：The basic concepts in 3D Printed Electronic Devices for 5G and Space Applications.

理解：The basic connotation in 3D Printed Electronic Devices for 5G and Space Applications.

掌握：The basic principles in 3D Printed Electronic Devices for 5G and Space Applications.

【3】重点内容：

The basic concepts and principle in 3D Printed Electronic Devices for 5G and Space Applications.

【4】难点内容：

The basic connotation in 3D Printed Electronic Devices for 5G and Space Applications.

（二）实验教学

The project names and the related information of class hours allocation for experimental teaching are shown in Table 2.

表 2　实验教学信息表

序号	实验项目名称	实验学时	每组人数	实验类型	实验性质
1	Diode I-V Characteristics; Transfer characteristics and Drain Characteristics for NMOS and PMOSTransistors	2	1	Design	Required
2	Tutorial 2: TransientAnalysis of a CMOS Inverter	2	1	Design	Required
3	Tutorial 3: Logic Gates: NAND/AND, NOR/OR,XOR/XNOR	4	1	Design	Required
4	Tutorial 4: Design a Combinational Circuit Using the Gates	4	1	Design	Required
5	Tutorial 5: An Automated System Using the Gates	4	1	Design	Required
6	Tutorial 6: Frequency Response of CMOS Operational Amplifier (op amp)	4	1	Design	Required
7	Tutorial 7: MEMS 1-Lateral Resonator	2	1	Design	Required
8	Tutorial 8: MEMS 2-Rotary Side Drive Electrostatic Motor	2	1	Design	Required
9	Tutorial 9: Photonics/Optics AC Small Signal Analysis of Interferometer	4	1	Design	Required

实验项目一：Diode I-V characteristics Simulation（支撑教学目标 1-1、1-2、1-5、2-1、2-2、2-3）

【1】实验内容：

（1）Be familiar with Tanner Tools method for designing, simulating.

（2）Diode I-V characteristic, Transfer characteristic and Drain characteristic simulation for NMOS and PMOS transistors.

【2】实验目的：

Simulate the diode I-V characteristic by tanner to understand deeply the working function of NMOS and PMOS.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目二：Transient analysis of a CMOS inverter（支撑教学目标 1-2、2-1、2-2、2-3）

【1】实验内容：

（1）Draw inverter characteristic circuit diagram by S-edit.

（2）Layout the inverter with L-Edit;

（3）Simulation results of the inverter by S-edit.

【2】实验目的：

Transient Analysis of an CMOS inverter，inverter layout by L-Edit. Deeply understand its working

function.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目三：Two-input logic gate experiment（支撑教学目标 1-1、1-5、2-1、2-2、2-3）

【1】实验内容：

（1）Draw and simulate or non-gate NOR circuit diagram.

（2）Draw and simulate the NAND circuit diagram.

【2】实验目的：

Deeply understand the working principle of AND, OR, and NON-gate logic circuits, draw their logic circuit diagrams and perform their transient analysis.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目四： Design a combinational circuit using the gates（支撑教学目标 1-2、1-4、1-5、2-1、2-2、2-3）

【1】实验内容：

（1）Create reverse, and , or gate symbols.

（2）Use the created inverter, and gate, or gate symbols to build an XOR gate and simulate it.

（3）Build the XOR gate layout using L-Edit.

【2】实验目的：

Understand the fundamentals of XOR gates, design a composite circuit with logic gates symbols, and build XOR gate layouts with L-Edit

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目五：An automated system made by using the logic gates symbols（支撑教学目标 1-4、1-5、2-1、2-2、2-3）

【1】实验内容：

（1）Construct XOR gate symbol and test it.

（2）ConstructNOR symbol and test it.

（3）A 4-bit comparator password detection system is constructed and simulated by using XOR and NOR symbol components.

【2】实验目的：

A 4-bit password detection system is designed using comparator.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目六：Frequency response of CMOS operational amplifier（支撑教学目标 1-1、1-2、1-3、2-1、2-2、2-3）

【1】实验内容：

（1）Draw the schematic diagram of CMOS operational amplifier and generate its part symbols.

（2）Use the generated CMOS symbols to draw the operational amplifier schematic.

（3）Simulate CMOS operational amplifier analog circuit.

【2】实验目的：

Deeply understand the basic principles of CMOS operational amplifiers and analyse the simulation result of the frequency response of CMOS operational amplifiers.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目七：MEMS 1-Lateral resonator（支撑教学目标 1-2、2-1、2-2、2-3）

【1】实验内容：

（1）Load pzelec library.

（2）Drawing piezoelectric circuit diagram and setting parameters.

（3）Simulation piezoelectric circuit diagram.

【2】实验目的：

Design MEMS 1-Lateral resonator.Understand the basic principles of piezoelectric circuits in Micro-systems and learn how to use PZELEC library component to draw circuit schematic.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目八：MEMS 2-Rotary side drive electrostatic motor（支撑教学目标 1-2、2-1、2-2、2-3）

【1】实验内容：

（1）Load the reason library and create a new unit cell.

（2）Plot the Resonator layout in L-Edit.

【2】实验目的：

Fully understand the internal structure of the resonator, using Tanner's L-Edit MEMS software to draw the layout of the resonator.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

实验项目九：Photonics/Optics AC small signal analysis of Interferometer （支撑教学目标 1-2、1-4、1-5、2-1、2-2、2-3）

【1】实验内容：

（1）Load the Optiwave library and create a new unit.

（2）Draw circuit diagram and set parameters.

（3）The Tannery waveform viewer was used for optical signal visualization.

【2】实验目的：

Understand the principle of optical interferometer and build optical interferometer with different retardation.

【3】教学要求：

Each student completes the experiment independently and writes the experiment report.

【4】实验方式：

Drawing circuit diagram and simulating it,software debugging.

【5】实验场地与设备：

Technology Building 6058, computer, soft Tanner software.

五、教学安排与学时分配

The distribution of class hours is shown in Table 3.

表 3 学时分配表

讲　　课　　内　　容		学时				
		讲课	实验	上机	设计	课外
第 1 章	Introduction to Components	2	2	0	0	0
第 2 章	Semiconductor Theory	4	4	0	0	0
第 3 章	CMOS Devices and Fabrication	2	2	0	0	0
第 4 章	Optoelectronics and LEDs	4	4	0	0	0
第 5 章	Introduction to MEMS	2	2	0	0	0
第 6 章	Advanced Electronic Devices	2	2	0	0	0
第 7 章	Frequency Response of CMOS	4	4	0	0	0
第 8 章	Packaging and Reliability	2	2	0	0	0
第 9 章	Software Defined Radios	2	2	0	0	0
第 10 章	Introduction to Lasers	2	2	0	0	0
第 11 章	3D Printed Electronic Devices for 5G	2	2	0	0	0
小计		28	28	0	0	0
总计	56					

六、教学方法

1、Multi-media-based lecturing

2、Combining theory with industrial practical problems.

3、Knowledge delivery with ethic education.

4、Problem-based learning.

七、成绩评定

1、 The examination form of this course is the final report, which is assessed according to the percentage system. Combined with the Ordinary performance,little quiz,oral representation and experimental performance.

(1) Test results and usual performance account for 10% of the final score.

(2) The score of the oral representation account for 10% of the final score.

(3) The result of the experiment report account for 10% of the final result.

(4) The final report score accounts for 70% of the final score.

2、Those who are missing more than 1/3 of the required amount of experiments and homework, or who are missing more than 1/3 of the planned class hours, or who fail to pass the experimental assessment, will be disqualified from the course assessment.

八、其他

1、Teaching syllabus

Assessment cycle: 4 years, revision cycle: 4 years.

Improvement measures: the course leader organizes all teachers in the course team to discuss and put forward improvement suggestions, which are reviewed by the director of the Teaching and Research Department and approved by the dean of teaching.

2、Performance assessment

Assessment period: 1 academic year, evaluation basis: comprehensive analysis of students' final scores.

Improvement measures: According to the distribution of students' final scores, the corresponding content adjustment and optimization, and improve the teaching method.

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