Engineering Design Theory & Methodology for Fabrication of Semiconductor Micro-Nano Devices

Department: Fudan International Summer Session 2022

Course Code			
Course Title	Engineering Design Theory & Methodology for Fabrication of Semiconductor Micro-Nano Devices		
Credit	2	**Credit Hours**	36 credit hours + 3 tutorial hours (one credit hour is 45 minutes)
Couse Nature	□Specific General Education Courses □Core Courses ☑General Education Elective Courses □Basic Courses in General Discipline □Professional Compulsory Courses □Professional Elective Courses □Others		
Course Objectives	Throughout the course, students will be led into the microscopic world of semiconductor micro-nano devices. They will comprehensively understand the basic elements, physical architecture and performance of semiconductor micro-nano devices, as well as the design principles and methods of constructing, fabricating and engineering implementation. This course will build a solid foundation for interdisciplinary postgraduates who are engaged in "New Engineering and Technical Disciplines" majors, especially those who are in the major of intelligent robots. The course enables student to design and apply semiconductor micro-nano devices more effectively and creatively.		
Course Description	Since the invention of semiconductor transistor and integrated circuit technology, various types of micro-nano devices derived from those techniques have played a more and more critical role in the industrial technology revolution. Semiconductor micro-nano devices have become the foundation of research in various new disciplines especially in emerging technical research and application areas such as Artificial Intelligence (AI), Big Data, Cloud Computing, Artificial Intelligent & Internet of Things (AIoT), etc. The economic and technical performance indicators (such as computing power, storage capacity, speed, energy consumption, reliability, cost, etc.) of semiconductor micro-nano devices are increasingly influencing and determining the development and direction of these new disciplines and related application fields. Therefore, it is necessary for interdisciplinary postgraduates who are engaged in "Emerging Engineering and Technical Disciplines" to take this course as one of the basic training programs, especially for those who major in intelligent robots. It is necessary for them to learn and understand design principles and methods of semiconductor micro-nano devices and their engineering implementation. The focuses of this course are materials, architecture, function and performance of semiconductor micro-nano devices. From the perspective of methodology, engineering design principles, current status and future trend are addressed in this course.		

Course Requirements:

Prerequisites:

Semiconductor physics, mechanical principles, physics, chemistry, material science

Teaching Methods:

Lectures and group discussion

Instructor's Academic Background:

Prof. Hua Zhou is a professor in Academy for Engineering and Technology, Fudan University. He received his Ph.D degree from the University of Connecticut in USA. He had served as senior scientist and technical and managerial officers in world-wide top fortune 500 company and internationally recognized semiconductor IC manufacturing companies as well.

He is one of key pioneers of copper interconnect technology for semiconductor integrated circuits in China. He has over 20 international and national invention patents and over 20 academic papers in international journals. He had won the First Place Prize of Shanghai Science Progress Award.

His research fields include the emerging IC memory technology, the design and manufacturing technology in advanced microprocessor based on RISC-V, the design and manufacturing technology for memory in computing, the heterogeneous integration technology for advanced AI IC chips, and In-situ control system for intelligent Robotics.

He also serves as the chief scientist of the Micro-Nano Engineering Technology Innovation Center in Shanghai Pilot Free Trade Zone Lin-gang Special Area, which is affiliated with Academy of Applied Engineering and Technologies of Fudan University.

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Course Schedule:

No.	Time	Content & Expected Achievement
1	Week 1	Course content: Introduction to semiconductor micro-nano devices Expectation: Understand and master the basic principles, history, current situation and future trends of semiconductor transistors, integrated technology and micro-nano devices
2	Week 1	Course content: Semiconductor micro-nano device materials, physical architecture, engineering design and principles，logic computing devices Expectation: Understand and master the design principles and strategies of device engineering，understand the characteristics of the Von-Neuman architecture, RISC-V (ISA) open source instruction set, the basic principles and trends of CPU, MCU, ASIC, FPGA etc.
3	Week 1	Course content: Memory devices Expectation: Understand the architecture and physical characteristics

		of main memory devices including SRAM, DRAM, PSRAM, ROM, EPROM and flash memory as well as the trend of emerging memory technology.
4	Week 2	Course content: Memory-In-Computing devices (MIC) Expectation: Understand the bottlenecks of the Von-Neuman architecture in emerging application industry scenarios such as storage walls and energy barriers. Understand the evolution and future trend of memory and computing integration technologies, such as GPU, HBM, TPU, CNN, etc.
5	Week 2	Course content: "Hard real-time" devices and systems for robot motion behavior Expectation: Understand the key contributing factors of robot motion behavior control and the solution of "hard real-time" control
6	Week 2	Course content: Challenges and methods of device engineering: digital graphics, additive engineering, subtractive engineering, heat treatment and other engineering design principles and methods, environmental and safety engineering design principles and methods (1) Expectation: Understand the design principles of digital graphics, additive/subtractive materials. Understand the thermodynamics and kinetic models and empirical formulas in the engineering method
7	Week 3	Course content: Challenges and methods of device engineering: digital graphics, additive engineering, subtractive engineering, heat treatment and other engineering design principles and methods, environmental and safety engineering design principles and methods (2) Expectation: Understand the principles and methods of transistor arrays and conduction network cables in engineering realization, and understand the manufacturing processes of integrated circuits such as photolithography (digital patterning), etching, injection, diffusion, heat treatment, cleaning, chemical mechanical planarization, etc.
8	Week 3	Course content: Design principles, methods, tools and material selection for engineering realization Expectation: Understand and master the design principles and methods of engineering to achieve disruptive technical routes
9	Week 3	Course content: Heterogeneous integrated packaging design, material process and reliability, heat dissipation consideration, etc. Expectation: Understand the trend of heterogeneous integrated packaging and More than Moore's law. Understand the key technologies of heterogeneous integration and the integrated method of sensing, storing and computing integrated systems
10	Week 4	Course content: System engineering and reliability, process control, inspection engineering, DOE/SPC tools and application methods

		Expectation: Master the ideological system and method of "tracing the source". Understand the future development trend of the post-silicon device era
11	Week 4	Questions and Answers on Course Design
12	Week 4	Course Design Report

The design of class discussion or exercise, practice, experience and so on:

Semiconductor micro-nano devices design and discussion.

Grading & Evaluation:

Assessment Criteria	Weight	Assessment Standard
Attendance	15%	Attendance
Participation	15%	Performance in class
Assignment	20%	Test score
Course Paper	50%	Overall Course design report
Other(s)		

Teaching Materials & References:

References:

No.	Title	Author(s)	ISBN/DIO	Publisher	Publication Date
1	Semiconductor Manufacturing Technology	Michael Quirk / Julian Serda	9787505394933	Publishing House of Electronics Industry	2004.1
2	Semiconductor Physics and Devices Basic Principles	Donald Neamen	9787121111808	Publishing House of Electronics Industry	2010.7
3	Computer Composition and Design: The Hardware/Software Interface Second Edition	David A.Patterson John L.Hennessy	9787111202141	Machinery Industry Press	2007.4
4	Ferroelectricity in Doped Hafnium Oxide:Materials,Properties and Devices	UWE SCHROEDER, CHEOL SEONG HWANG, HIROSHI FUNAKUBO	9780081024300	Woodhead Publishing	2019

	5	MCU SoC system Based on RISC-V Like Open Source Instruction Set: Design, Control and Realization	Fei Ye, Weize Xie, Hua Zhou, Jicun Lu	Handouts by Instructor	/	Plan to Publlish

Textbook(s)

No.	**Title**	**Author(s)**	**ISBN**	**Publisher**	**Publication Date**
1	Nanoscale Integrated Circuits - The Manufacturing Process Second Edition	Rujing Zhang etc.	9787302452331	Tsinghua University Press	2014.7