Preferred course/module

(1) Module I: Process integration: Chemical/Material Engineering

	Dept./Inst.	Course Title	Time (For AY 114; AY 115 arrangements may change)	Instructor	Remarks
1	College of Semiconductor Research	Semiconductor Lithography	Wed. Periods 7-8 Fri. Periods 7-8	Prof. Ben-chien Li 林本堅	
2	College of Semiconductor Research	Introduction to Semiconductor Process	Fri. Periods 7-8	Prof. Kaixin Li 李愷信	Syllabus from previous instructor for AY 113; final instructor subjects to department assignment.
3	Department of Chemistry	Analytical techniques for Materials Chemistry	Thu. Periods 2-4	Prof. Chia-Min Yang 楊家銘	
4	Institute of NanoEngineering and MicroSystems	Polymer Micro/Nano System Technology	Wed. Periods 5-7	Prof. Chien-Chun Fu 傅建中	

(2) Module II: Semiconductor Device: Solid state physics

	Dept./Inst.	Course Title	Time (For AY 114; AY 115 arrangements may change)	Instructor	Remarks
5	College of Semiconductor Research	Introduction to Semiconductor Memories	Thu. Periods 5-7	Prof. Wei Su 蘇韋	Syllabus from the same instructor for AY 113.

6	College of Semiconductor Research	Introduction to Semiconductor Device	Fri. Periods 3-4	Prof. Yonghua Zeng 曾永華	
7	College of Semiconductor Research	3D and Next Generation Memories	Thu. Periods 6-8	Prof. Shirata Riichiro 白田理一郎	
8	Department of Physics	Semiconductor Physics	Fri. Periods 5-7	Prof. Wei-Ting Hsu 徐瑋廷	
9	Electrical Engineering	Introduction to Solid-State Electronic Devices	Wed. Periods 3-4 Fri. Periods 3	Prof. Chongrong Lin 林崇榮	
10	Institute of Electronics Engineering	Quantum Mechanics	Thu. Periods 7-9	Prof. Jianyuan Zhang 張鑑元	Syllabus from previous instructor for AY 113; final instructor subjects to department assignment.

課程資訊 (Course Information)					
科號 Course Number	11410CSR 540300	學分 Credit	3	人數限制 Class Size	40
中文名稱 Course Title	半導體微影、RET、Immersion、EUV				
英文名稱 Course English Title	Semiconductor Lithography				
任課教師 Instructor	林本堅(LIN, BURN-JENG) *more information*				
上課時間 Time	W7W8F7F8	上課教室 Room	GEN III綜三LRA		

提醒您：請遵守智慧財產權，勿使用非法影印教科書
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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	

課程簡述 (Brief course description)

This course covers the key aspects of nanolithography in theory, practice, and innovations on diffraction-ba<x>sed imaging as well as materials, equipment, and processing in nanolithography. There is also coverage on well-proven as well as exploratory systems to expose students to many different situations, providing opportunities to train students in creativity, logical thinking, and problem solving, as well as equipping them for R&D and production engineering work in semiconductor companies. 這門課包含光波繞射、奈米微影材料、奈米微影機台、和奈米微影製程的理論、應用、和創新的基本觀念；也包括各種成熟 和尚在開發中的奈米微影系統給學生們機會考量各種不同的情況，來促進他們創新、邏輯思考、和解決問題的能力，裝備學 生們在半導體公司研發和生產的能力。

課程大綱 (Syllabus)

Course keywords:
Nanolithography theory and practice 奈米微影理論和應用，Nanolithography materials 奈米微影材料，
Nonolithography equipment 奈米微影機台，EM wave diffraction 光波繞射

課程大綱
This course is intended to equip students with theoretical and practical skills
in nanolithography for doing research and for patterning nanometer semiconductors
in massive and experimental quantities. A broader objective is to use high-
resolution imaging as a vehicle to train students on innovative thinking and
problem solving.
這門課教導理論和實用的奈米微影技術使學生們既能做奈米微影的研究，也能用奈米微影成像的技術
幫助奈米微影級半導體的量產和試產。更廣的目的是藉奈米微影學的平台，訓練學生用創意思考並用創
意解決問題。

五大關鍵
Nanolithography theory 奈米微影理論，
Nanolithography practice 奈米微影應用，
Nanolithography materials 奈米微影材料，
Nanolithography systems 奈米微影系統，
EM wave diffraction 光波繞射

教科書 "Optical Lithography; Here is Why" Burn J. Lin, SPIE Press 2021

參考書目 "Principles of Optics" Born & Wolf, any edition
"Introduction to Microlithography" L.F. Thompson, C.G. Willson, and M.J. Bowden,
ACS Professional Reference Book, 1994
"Molecular theory of Lithography" Uzodinma Okoroanyanwu, SPIE Press 2015

內容綱要
This course is intended to equip students with theoretical and practical skills in nanolithography for doing research and for patterning nanometer semiconductors in massive and experimental quantities. A broader objective is to use high-resolution imaging as a vehicle to train students on innovative thinking and problem solving.
這門課教導理論和實用的奈米微影技術使學生們既能做奈米微影的研究，也能用奈米微影成像的技術幫助奈米微影級半導體的量產和試產。更廣的目的是藉奈米微影學的平台，訓練學生用創意思考並用創意解決問題。

Technology and systems
1. Exposure systems
2. Processing systems
3. Imaging and resolution enhancement
4. Alignment and overlay
5. Metrics and metrology
6. Masks
7. Immersion lithography
8. EUV lithography

對應之學生核心能力
微影領域之專業知識 Professionalism in the nanolithography
創新、邏輯思考、和解決問題的能力。Ability to innovate & solve problems

教學要點概述：
1. 教材編選：老師自著教科書，自編投影片
2. 教學方法：教學、討論、作業、考試
3. 評量方法：學生在課堂上的表現(加分)，作業30%、期中考30%、期末考40%

課程資訊 (Course Information)					
科號 Course Number	11310CSR 540100	學分 Credit	2	人數限制 Class Size	100
中文名稱 Course Title	半導體製程導讀				
英文名稱 Course English Title	Introduction to Semiconductor Process				
任課教師 Instructor	黃健朝(HUANG, CHIEN-CHAO) *more information*				
上課時間 Time	F5F6	上課教室 Room	CHEM II化二 223		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	

課程簡述 (Brief course description)

Process integration is one of the most knowledge in CMOS devices towards smaller, faster and less expensive fabrication. However, there are still many challenges in the novel application and fundamental understanding of the device process with the associated key process modules. In this course, three directions are expected to: 1) To introduce fundamental knowledge of major process modules & integration 2) To construct a comprehensive thinking model in device integration 3) To build up the ability in analyzing CMOS device structure/process/integration

課程大綱 (Syllabus)

Course keywords:
黃光(photolithography), 蝕刻 (etching), 離子佈植 (ion implant), 磊晶 (epitaxy), 擴散 (diffusion), 清洗 (Clean), 物理氣相沉積 (PVD), 化學氣相沉積 (CVD), 機械化學研磨 (CMP), 熱預算 (thermal budget)

一、課程說明：
In this course, both experimental and theoretical contributions of CMOS process technology & integration are included. Four major topics : 1) CMOS process introduction; 2) CMOS key process module introduction; 3) Device structure/integration introduction; 4) Future device technology development & challenge introduction

二、教學方式:

Classes will be taught with PowerPoint presentations, and the course materials and supplementary teaching materials will be uploaded after the class

三、成績考核:
1. Attendence: 10%
2. Homework: 30%
3. Mid.Exam. (8th week): 30%
4. Final Exam. (16th week): 30%

四、課程內容大綱：
Major topics to introduce process technology & integration in CMOS device:
1) CMOS process introduction: Overview the development history of CMOS technology & process/integration application in CMOS device.
2) CMOS key process module introduction: Photo, etching, diffusion, epitaxy, clean, CMP, PVD & CVD process module.
3) Device structure/integration introduction: front-end & middle-end & backend process integration in planar/FinFET devices.
4) Device technology development & challenge Introduction: Highlight in recently device technology development & challenge especially in FinFET/Nanosheet/

GAA device structure.

五、擬用教科書，參考書或教材來源：
教科書： 1. S. Wolf, Silicon Processing for the VLSI Era, ISBN 0-9616721-3-7 (volume 1) & ISBN 0-9616721-4-5 (volume 2)
2. 蕭宏,半導體製程技術導論,全華圖書, (第三版), 2014

六、採用下列何項 AI 使用規則 (Indicate which of the following options you use to manage student use of the AI): 本課程無涉及AI使用(Not applicable)

課程資訊 (Course Information)					
科號 Course Number	11410CHEM543000	學分 Credit	3	人數限制 Class Size	25
中文名稱 Course Title	材料化學分析技術				
英文名稱 Course English Title	Analytical techniques for Materials Chemistry				
任課教師 Instructor	楊家銘(YANG, CHIA-MIN) *more information*				
上課時間 Time	R2R3R4	上課教室 Room	CHEM化 326		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	■ 化學專業知識 (70%) expertise in chemistry (70%) ■ 英文閱讀/聽解/書寫 (20%) English reading/listening/writing (20%) □ 溝通與團隊合作 communication skill and team work ■ 資料檢索/整理/表達/應用 (10%) data retrieving, analysis, expression and application (10%) □ 實驗與儀器操作 experimental and instrumental operation □ 數理運算解析 scientific logic analysis

課程簡述 (Brief course description)

The course offers introduction to the selected techniques of materials characterizations. The selected techniques include Auger electron spectroscopy, X-ray photoelectron spectroscopy, low energy electron diffraction, scanning probe microscopy, powder X-ray diffraction, X-ray absorption spectroscopy, gas physisorption, scanning electron microscopy, transmission electron microscopy, and energy-dispersive X-ray spectrometry.

課程大綱 (Syllabus)

Course keywords:
表面分析技術（Surface analysis techniques），Ｘ光粉末繞射（X-ray powder diffraction），氣體物理吸附分析（Gas physisorption analysis），Ｘ光吸收光譜術（X-ray absorption spectroscopy），電子顯微鏡與相關分析技術（Electron microscopy and related techniques）

一、課程說明(Course Description)
General course information:
Course title/number: Analytical techniques in materials chemistry / CHEM5430
Time: R2R3R4
Location: 化學館 326 教室
Credit: 3

Instructor information:
Name: 楊家銘（Chia-Min Yang）
Office: 化二館 225A 室
Ext: 31282
e-mail: cmyang@mx.nthu.edu.tw

Contents of the course:
1) Introduction to techniques for surface analysis

X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), low energy electron diffraction (LEED), scanning probe microscopy (SPM)

2) X-ray diffraction (XRD)
Principles of X-ray crystallography, powder X-ray diffraction

3) X-ray absorption spectroscopy (XAS)
Principles of X-ray absorption spectroscopy, experimental methods and data analysis

4) Gas physisorption analysis
Fundamentals of physisorption, BET method, BJH method, t-plot analysis

5) Electron microscopies and related analytical techniques
Scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy-dispersive X-ray spectrometry (EDS)

二、指定用書(Text Books)
Not available.

三、參考書籍(References)

General
D. Brandon and W. D. Kaplan, "Microstructural Characterization of Materials", 2nd ed., Wiley, 2008.

Surface analysis
J. C. Vickerman and I. S. Gilmore (eds.), "Surface Analysis-The Principal Techniques", 2nd ed., Wiley, 2009
.

X-ray diffraction
1. J. P. Glusker and K. N. Trueblood, "Crystal Structure Analysis-A Primer", 3rd ed., Oxford University Press,
2010.
2. C. Giacovazzo, (ed.), "Fundamentals of Crystallography", Oxford University Press, 1992.
3. W. David et al. (eds.), "Structure Determination from Powder Diffraction Data", Oxford University Press, 2002.

X-ray absorption spectroscopy
1. B. K. Teo, "EXAFS: Basic Principles and Data Analysis", Springer-Verlag, 1986.
2. G. Bunker, “Introduction to XAFS: A Practical Guide to X-ray Absorption Fine Structure Spectroscopy”, Cambridge University Press, 2010.
3. Y. Iwasawa et al. (eds.), “XAFS Techniques for Catalysts, Nanomaterials, and Surfaces”, Springer, 2017.

Gas physisorption
S. Lowell et al., “Characterization of Porous Solids and Powders: Surface Area, Pore Size and Density”, Springer, 2004.

Electron microscopy
1. D. B. Williams and C. B. Carter, "Transmission Electron Microscopy – A Textbook for Materials Science", 2nd
ed., Springer, 2009.
2. C. B. Carter et al. (eds.), " Transmission Electron Microscopy: Diffraction, Imaging, and Spectrometry ", Springer, 2016.
3. J. I. Goldstein et al., “Scanning Electron Microscopy and X-Ray Microanalysis”, 4th ed., Springer, 2017.

四、教學方式(Teaching Method)
Lectures (PowerPoint)

五、教學進度(Syllabus)
1. Introduction to surface analysis, XPS, AES
2. LEED, SPM
3. Introduction to diffraction analysis
4. XRD
5. XAS
6. Gas physisorption
7. SEM, EDS
8. TEM

六、成績考核(Evaluation)
Midterm exam (40%)
Final exam (50%)
Term paper (10%)

七、採用下列何項 AI 使用規則 (Indicate which of the following options you use to manage student use of the AI)
Not applicable

八、可連結之網頁位址
Not available.

課程資訊 (Course Information)					
科號 Course Number	11410NEMS550100	學分 Credit	3	人數限制 Class Size	28
中文名稱 Course Title	高分子微奈米系統技術				
英文名稱 Course English Title	Polymer Micro/Nano System Technology				
任課教師 Instructor	傅建中(FU, CHIEN-CHUNG) *more information*				
上課時間 Time	W5W6W7	上課教室 Room	DELTA台達321		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	■ 具備優質的外語能力與國際觀 (20%) Excellent foreign language skills and a global perspective (20%) ■ 具備紮實的工程基礎知識及技術 (20%) Solid knowledge and sound skills of engineering (20%) ■ 培養具備異質領域整合、溝通與協調能力之領導人才 (20%) Leadership skills in interdisciplinary integration, communication and coordination (20%) ■ 具備能夠獨立思考、研發設計與實務執行之能力。 (20%) Independent thinking and the ability to innovate and implement new ideas in practice (20%) ■ 培養自我學習、持續創新及具有冒險勇氣的領導人才 (20%) Abilities of self-learning and continuous innovation, and courageous and risk-taking leadership (20%)

課程簡述 (Brief course description)

本課程透過LIGA技術的發展史, 一步一步帶領學生認識各種高分子微奈米加工技術, 包含 X光微影技術(X-Ray Lithography), 電子束微影(E-beam Lithography), 離子束微影(Ion-beam Lithography),反應式離子蝕刻(Reactive Ion Etching), 電鍍(Electroplating), 成型技術(Molding), 雙光子聚合(Two-Photon Polymerization)等 期末將安排半導體相關企業或是國家實驗室參訪, 讓同學能對LIGA或半導體技術有所認識。 This course guides students step-by-step through the history of LIGA technology development, introducing various polymer micro- and nano-fabrication techniques. These include: X-ray Lithography E-beam Lithography Ion-beam Lithography Reactive Ion Etching Electroplating Molding Two-Photon Polymerization At the end of the course, visits to the National Synchrotron Radiation Research Center, national laboratories, or relevant enterprises will be arranged, allowing students to gain an understanding of LIGA technology.

課程大綱 (Syllabus)

Course keywords:
X光微影技術(X-Ray Lithography), 電子束微影(E-beam Lithography), 離子束微影(Ion-beam Lithography), 反應式離子蝕刻(Reactive Ion Etching), 電鍍(Electroplating), 成型技術(Molding), 雙光子聚合(Two-Photon Polymerization)

各位的同學,
這個學期的課程將以實體上課, 上課的教室將在台達館321教室。
但仍會保留部分彈性遠距。
以下是本次課程暫訂的Syllabus，課程內容會視實際的狀況動態調整。
本學期會使用line群組和EECLASS, 請確定修課的同學屆時加入群組。

Dear Students,

This semester's course will be conducted in person, and classes will be held in Room 321 of the Delta Building. However, some flexibility for remote learning will still be maintained.

Below is the tentative syllabus for this course. The content may be adjusted dynamically based on actual circumstances. This semester, we will use a LINE group

and EECLASS for communication. Please make sure to join the group if you are enrolled in the course.

11310 NEMS5501 高分子微奈米系統技術
11310 NEMS5501 Polymer Microsystems Technology
W567 @ 台達321教室 (Delta Building R321)

Week Date Syllabus 課程安排
1 2025.09.03 Introduction and Opening the Course
2 2025.09.10 Orientation
3 2025.09.17 X-Ray Mask and X-Ray Lithography I
4 2025.09.24 X-Ray Mask and X-Ray Lithography II
5 2025.10.01 E-beam RIE and AMANDA
6 2025.10.08 X-Ray Mask and X-Ray Lithography III
8 2025.10.15 Galvanic Deposition
9 2025.10.22 Plastic Molding in the LIGA Process
10 2025.10.29 Midterm Exam
11 2025.11.05 Variations and Additional Steps of the LIGA Process
12 2025.11.12 運動會
13 2025.11.19 Mid-Term Report I
14 2025.11.26 Mid-Term Report II
15 2025.12.03 Mid-Term Report III
16 2025.12.10 Company/National Lab Visiting
17 2025.12.17 Final Exam

Grading: (based on the ranking in the class)
Mid-Term Exam: 25%
Mid-Term Report: 25%
Final Exam: 20%
Weekly reports and class participation: 30%
Textbook: Microsystem Technology, W. Menz, J. Mohr, O. Paul, Wiley-VCH Ch.7~Ch.10
Mid-Term Report/Supplementary Material:
LIGA and it Applications, Brand etc., Wiley-VCH Ch.8-Ch.19。
Optical Lithography, Here is Why, by Burn Lin, SPIE Ch.3-Ch.8

本課程請勿使用AI。This course prohibits the use of AI.

課程資訊 (Course Information)					
科號 Course Number	11310CSR 520300	學分 Credit	3	人數限制 Class Size	35
中文名稱 Course Title	半導體記憶體導論				
英文名稱 Course English Title	Introduction to Semiconductor Memories				
任課教師 Instructor	蘇韋(DE SOURAV) *more information*				
上課時間 Time	R2R3R4	上課教室 Room	GEN III綜三LRB		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	

課程簡述 (Brief course description)

This course provides an in-depth understanding of semiconductor memory technologies, focusing on current industry scaling trends and state-of-the-art technologies. The topics covered include SRAM, DRAM, and Flash bit-cell architectures, along with memory array design. The first section of the course delves into the common semiconductor memory technologies, while the second section explores innovative memory technology applications for machine/deep learning and upcoming memory candidates that have the potential to reshape the memory hierarchy. The course is designed for graduate students in electrical and computer engineering programs, as well as professionals and researchers in the semiconductor and microelectronics industries.

課程大綱 (Syllabus)

Course keywords:
semiconductor memory, Static random access memory, dynamic random access memory, ferroelectric memory, Flash memory, resistive memory

Sylllabus:

Week 1 (9/5/2024) Introduction and Review of Semiconductor Device Physics
Week 2 (9/12/2024) Review of Semiconductor Device Physics
Week 3 (9/19/2024) MOS Capacitor
Week 4 (9/26/2024) MOSFETs
Week 6 (10/3/2024) SRAM and DRAM
Week 7 (10/17/2024) SRAM and DRAM Circuit Design
Week 8 (10/24/2024) 1st-term Examination
Week 9 (10/31/2024) Flash Memory
Week 10 (11/7/2024) Flash Memory
Week 11 (11/14/2024) Memory Array Design
Week 12 (11/21/2024) Emerging Non-Volatile Memories
Week 13 (11/28/2024) Emerging Non-Volatile Memories-II
Week 14 (12/5/2024) Emerging topics
Week 14 (12/12/2024) Presentation
Week 16 (12/16/2024) Final Exam

Type of Evaluation % Contribution in Grade

Final Presentation 30
1st-term examination 30
Final Examination 40

Reference book:
1. Class room lectures and notes
2. Nonvolatile semiconductor memory technology : a comprehensive guide to

understanding and to using NVSM devices
Brown, William D., 1943-; Brewer, Joe (Joe E.) 1998.
3. Low Power and Reliable SRAM Memory Cell and Array Design
Ishibashi, Koichiro ; Osada, Kenichi; Osada, Kenichi ; Ishibashi, Koichiro ;
Osada, Kenichi ; Ishibashi, Koichiro
Springer series in advanced microelectronics, 2011, Vol.31
4. Charge-Trapping Non-Volatile Memories : Volume 2--Emerging Materials and
Structures.
Dimitrakis, Panagiotis; Dimitrakis, Panagiotis

Use of AI for assignment and examinations are strictly prohibited

課程資訊 (Course Information)					
科號 Course Number	11410CSR 510100	學分 Credit	2	人數限制 Class Size	100
中文名稱 Course Title	半導體元件導論				
英文名稱 Course English Title	Introduction to Semiconductor Device				
任課教師 Instructor	張鑑元(CHANG CHIEN-YUAN) *more information*				
上課時間 Time	F3F4	上課教室 Room	PHYS物 124		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	

課程簡述 (Brief course description)

Welcome to solid-state physics! This lecture will build the basic understanding of physics at the undergraduate level of students from various background. In order to prepare everyone for this topic, the lecture will cover the following elements in solid-state. 1. Chemistry (needed in this lecture) 2. Quantum physics (needed in this lecture) 3. Statistical mechanics (needed in this lecture) 4. Electrical properties – Electron in solid 5. Heat properties – Phonons in solid 6. Optical properties – band structures and excitons 7. Crystal structures 8. Semiconductor devices 9. Magnetic properties of atoms Three textbooks are recommended for this lecture. I will opt a modern aspect and interpretation of solid-state physics, The Oxford solid state basics, as the main materials. Simon, Steven H. The Oxford solid state basics. OUP Oxford, 2013. Kittel, Charles. Introduction to solid state physics. Ashcroft, N. W., and N. D. Mermin. "Solid State Physics"

課程大綱 (Syllabus)

Course keywords:
solid-state physics, chemistry and crystal, fundamental properties and their elements, quantum physics and statistical mechanics

採用下列何項 AI 使用規則 (Indicate which of the following options you use to manage student use of the AI):
有條件開放，請註明如何使用生成式AI於課程產出 Conditionally open; please specify how generative AI will be used in course output
See the condition here: https://curricul.site.nthu.edu.tw/p/404-1208-248357.php?Lang=zh-tw

課程資訊 (Course Information)					
科號 Course Number	11410CSR 510200	學分 Credit	3	人數限制 Class Size	30
中文名稱 Course Title	三維及次世代記憶體				
英文名稱 Course English Title	3D and Next Generation Memories				
任課教師 Instructor	白田理一郎(RIICHIRO SHIROTA) *more information*				
上課時間 Time	R5R6R7	上課教室 Room	GEN III綜三 734		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	

課程簡述 (Brief course description)

Semiconductor memories have mainly two uses. One is for the calculation by exchanging data with CPU, MPU, etc. The other is for the mass data storage. Demands for these two applications are following; 1. Low cost and high density, 2. High speed operation, 3. Low power consumption. Therefore, memory technologies have been evolved more than 30 years to satisfy these demands. Moreover, new application has been noticed for the calculation of AI which is called in memory computing. Furthermore, memory device and CPU/MPU are connected chip-to-chip and can get quite high speed and low power operation. I will introduce these new technologies. Following are the outline of the course. Part1: Basic concept of memories: 1. DRAM & SARM 2.NOR-Flash 3. NAND-Flash Part2: 1. 3D NAND, In-memory computing for AI calculation.

課程大綱 (Syllabus)

Course keywords:
Semiconductor memory, Flash memory, DRAM, 3 dimensional memory cell, In memory computing

Syllabus of the course (3D and Next Generation Memories), from 2025 September

Recent semiconductor memory technologies are studied in this course.

Part 1. Fundamentals of MOSFET operation
Part 2. Basic concept of the semiconductor memories
1. DRAM & SARM
2. NOR-Flash
3. NAND-Flash
Part 3. Recent device and process technologies of 3D NAND-Flash
Part 4. Reliability of NAND-Flash
Part 5. Issues of recent DRAM and its new technology trend
Part 6. New application of memory: in memory computing for AI

Soring method:
attendance score = 20%, middle quiz = 40%, final quiz = 40%.

課程資訊 (Course Information)					
科號 Course Number	11410PHYS573000	學分 Credit	3	人數限制 Class Size	
中文名稱 Course Title	半導體物理				
英文名稱 Course English Title	Semiconductor Physics				
任課教師 Instructor	徐瑋廷(HSU, WEI-TING) *more information*				
上課時間 Time	F5F6F7	上課教室 Room	PHYS物 019		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	■ 中階物理知識 (25%) Middle level knowledge of physics (25%) □ 自主學習能力 Independent learning capability ■ 物理相關數學能力 (20%) Mathematical capability in physics (20%) □ 物理實驗能力 Capability of physics experiment ■ 研究導向物理知識 (35%) Knowledge about physics research (35%) □ 計劃組織能力 capability of planning and organization ■ 高階物理知識 (20%) High level knowledge of physics (20%) □ 基礎物理知識 Basic level knowledge of physics □ 溝通表達能力 Capability of communication and expression □ 團隊合作能力 Capability of collaboration

課程簡述 (Brief course description)

本課程之目標設定在傳授近代半導體材料與元件之基本原理、半導體元件之設計概念以及半導體應用實例介紹。 This course will introduce the fundamental principles of modern semiconductor materials and devices, the design concepts of semiconductor devices, and the application examples of semiconductor devices.

課程大綱 (Syllabus)

Course keywords:
晶體結構(crystal structure), 電子能帶結構(electronic band structure), 載子濃度(carrier concentration), 費米能階(Fermi energy level), 平衡/非平衡載子傳輸(equilibrium/non-equilibrium carrier transport), p-n接面/二極體(p-n junction/diode), 異質接面(heterojunction)

觀看上傳之檔案(.pdf) (若無法直接開啟，請按右鍵，選擇＜另存目標＞後再行查閱)

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半導體物理
Semiconductor Physics

Instructor **(開課教師)**	Wei-Ting Hsu, Ph.D.
Course description **(課程簡介)**	The course objective is to internalize the fundamental physical principles of semiconductor materials. This course is suitable for undergraduate/graduate students majoring in science and engineering. Course topics include semiconductor crystal structure, electronic band structure, carrier concentration/Fermi energy level, equilibrium/non-equilibrium carrier transport properties, and *p*-*n* junction/diode.
Prerequisites **(先修課程)**	Calculus (I) (II), General Physics (I) (II), Modern Physics (I)
Textbook **(教課書)**	Donald A. Neamen, ***Semiconductor Physics and Devices: Basic Principles,*** *4/e, McGraw-Hill, 2012.*
References **(參考書籍)**	Simon M. Sze, Yiming Li, and Kwok K. Ng, ***Physics of Semiconductor Devices,*** *4/e, Wiley, 2021.* ***Lecture notes and slides***
Course Grading **(課程評分)**	***30% Homework*** ***35% Midterm exam*** ***35% Final exam***

Class Schedule (教學進度)

Week	Lecture Topic	Outline	Grading
1	Ch. 1. The Crystal Structure of Solids	Course Overview, Primitive and Unit Cell, Crystal Structures, and Miller Indices	
2		The Diamond Structure, Atomic Bonding, Imperfections, and Impurities in Solids	**HW-1**
3	Ch. 2. Introduction to Quantum Mechanics	Selected Topics from Quantum Mechanics, Schrödinger's wave equation, the Infinite Potential Well, the Step Potential Function, the Potential Barrier and Tunneling, and the One-Electron Atom	**HW-2**
4	Ch. 3. Introduction to the Quantum Theory of Solids	Formation of Energy Bands, the Kronig-Penney Model, and the *k*-Space Diagram	
5		The Energy Band, the Bond Model, Effective Mass, Hole, and the band structure of Si and GaAs	
6		Density of States Function, and Fermi-Dirac distribution	**HW-3**
7	Ch. 4. The Semiconductor in Equilibrium	Equilibrium Distribution of Electrons and Holes, the Intrinsic Carrier Concentration, and Fermi-Level Position	
8		The Extrinsic Semiconductor, Donor and Acceptor, Fermi Level and Carrier Concentration, Temperature effect	**HW-4**
9	Review of Ch. 1-4		**Midterm exam**
10	Ch. 5. Carrier Transport Phenomena	Carrier Drift and Mobility, Conductivity, Impurity Concentration, and Temperature Effect	
11		Carrier Diffusion, the Einstein Relation, and the Hall effect	**HW-5**
12	Ch. 6. Nonequilibrium Excess Carriers in Semiconductors	Carrier Generation and Recombination, Continuity Equation, Diffusion Equation	
13		Ambipolar Transport, Quasi-Fermi Energy Levels, Excess Carrier Lifetime	**HW-6**
14	Ch. 7. The *pn* Junction	Basic Structure, Built-in Potential Barrier, Space Charge Region, and Reverse Applied Bias	
15		Junction Breakdown, and Nonuniformly Doped Junctions	**HW-7**
16	Review of Ch. 5-7		**Final exam**

課程資訊 (Course Information)

科號 Course Number	11410EE 335000	學分 Credit	3	人數限制 Class Size	100
中文名稱 Course Title	固態電子元件導論				
英文名稱 Course English Title	Introduction to Solid-State Electronic Devices				
任課教師 Instructor	林崇榮(LIN, CHRONG JUNG) *more information*				
上課時間 Time	W3W4F3	上課教室 Room	DELTA台達215		

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此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	■ 豐富的數學、物理、科學與工程知識，以及實際運用的能力 (40%) An ability to learn profound knowledge in mathematics, physics, and science, as well as to apply the knowledge to engineering problems. (40%) □ 設計實驗、執行實驗、分析數據及歸納結果的能力 An ability to design and conduct experiments, as well as to analyze data and interpret results. ■ 執行電機工程實務所需理論、方法、技術及使用相關軟硬體工具之能力 (30%) An ability to use the theories, methods, techniques, and related necessary software/hardware tools for electrical engineering practice. (30%) ■ 電機工程系統、模組、元件或製程之設計能力 (15%) An ability to design electrical engineering systems, modules, components, or processes. (15%) □ 團隊合作所需之組織、溝通及協調的能力 An ability to organize, communicate, and coordinate for teamwork. ■ 發掘問題、分析問題及處理問題的能力 (10%) An ability to identify, analyze, and solve problems. (10%) ■ 掌握科技趨勢，並了解科技對人類、環境、社會及全球的影響 (5%) An awareness of the technology trends and their human/environmental/social/global impacts. (5%) □ 理解專業倫理及社會責任 An understanding of professional ethics and social responsibilities. □ 專業的外語能力及與國際社群互動的能力 An ability to communicate professionally in a foreign language, as well as to interact with international communities.

課程簡述 (Brief course description)

The course of “Introduction to Solid-State Electronic Devices” (固態電子元件導論) is a foundational course designed for undergraduate students who wish to acquire a comprehensive understanding of semiconductor devices, including their fundamental characteristics, mechanisms, and underlying physics. In this course, students will learn important topics such as semiconductor band theory, carrier transportation and conduction in semiconductors, semiconductor junctions and diodes, MOS capacitors, MOSFETs, bipolar transistors, as well as VLSI memory technologies. Additionally, this course incorporates contemporary knowledge on semiconductor devices, ensuring students stay up to date with the latest advancements in the semiconductor field.

課程大綱 (Syllabus)

Course keywords:
Semiconductor, Device Physics, VLSI, Integrated Circuit, Transistor, Diode, BJT, MOSFET

觀看上傳之檔案(.pdf) (若無法直接開啟，請按右鍵，選擇＜另存目標＞後再行查閱)

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Introduction to Solid-State Electronic Devices
固態電子元件導論

EE 335000 固態電子元件導論
Introduction to Solid-State Electronic Devices

- Professor: 林崇榮 Chrong Jung Lin
- TA: TBD
- Course Handouts (download from EEClass)
- Reference Books

1. Fundamentals of Semiconductor Devices (Ref.)

   by Betty L. Anderson & Richard L. Anderson

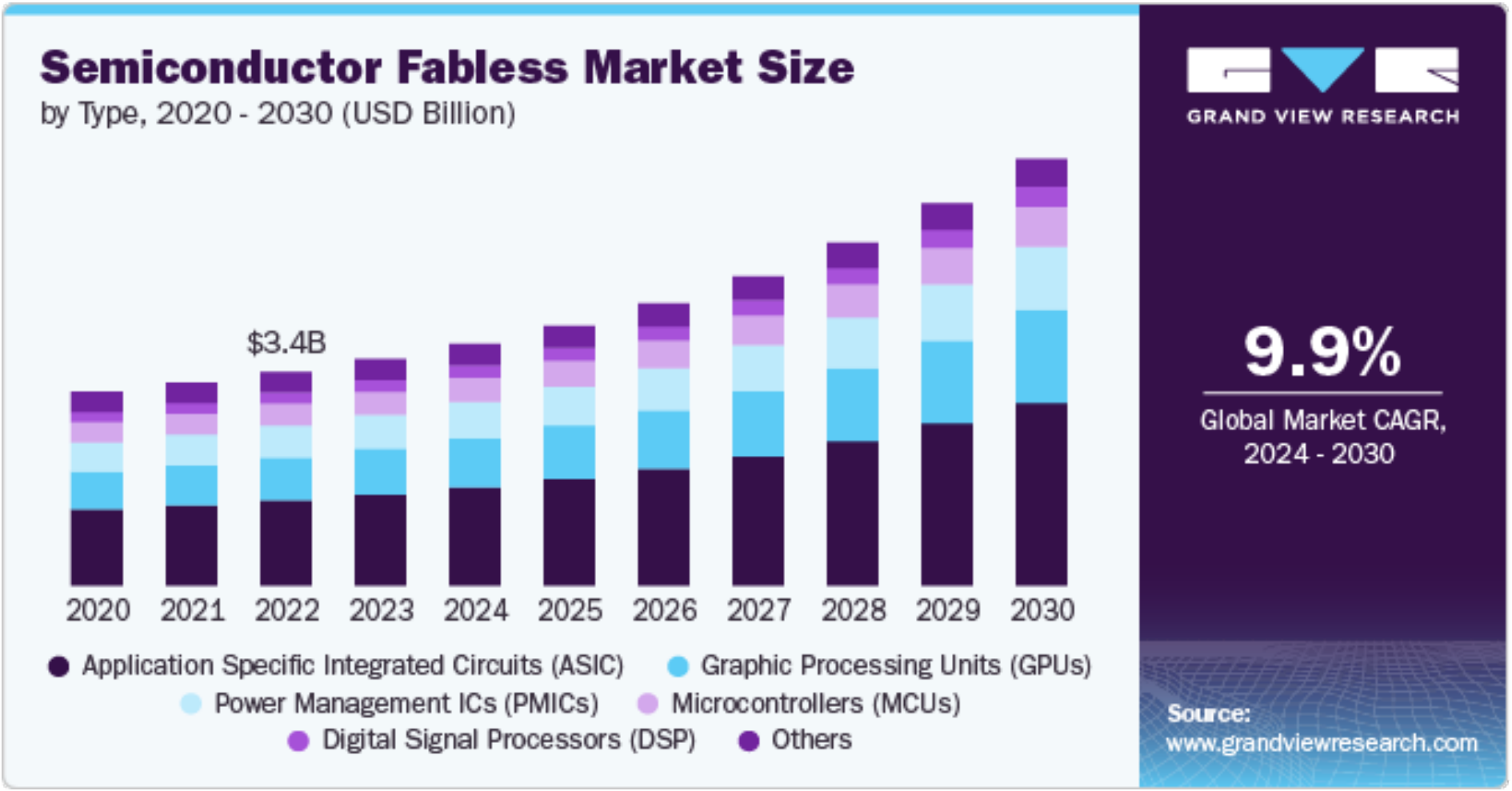
2. Physics of Semiconductor Devices (Ref.)

   by Simon M. Sze, Yiming Li, Kwok K. N

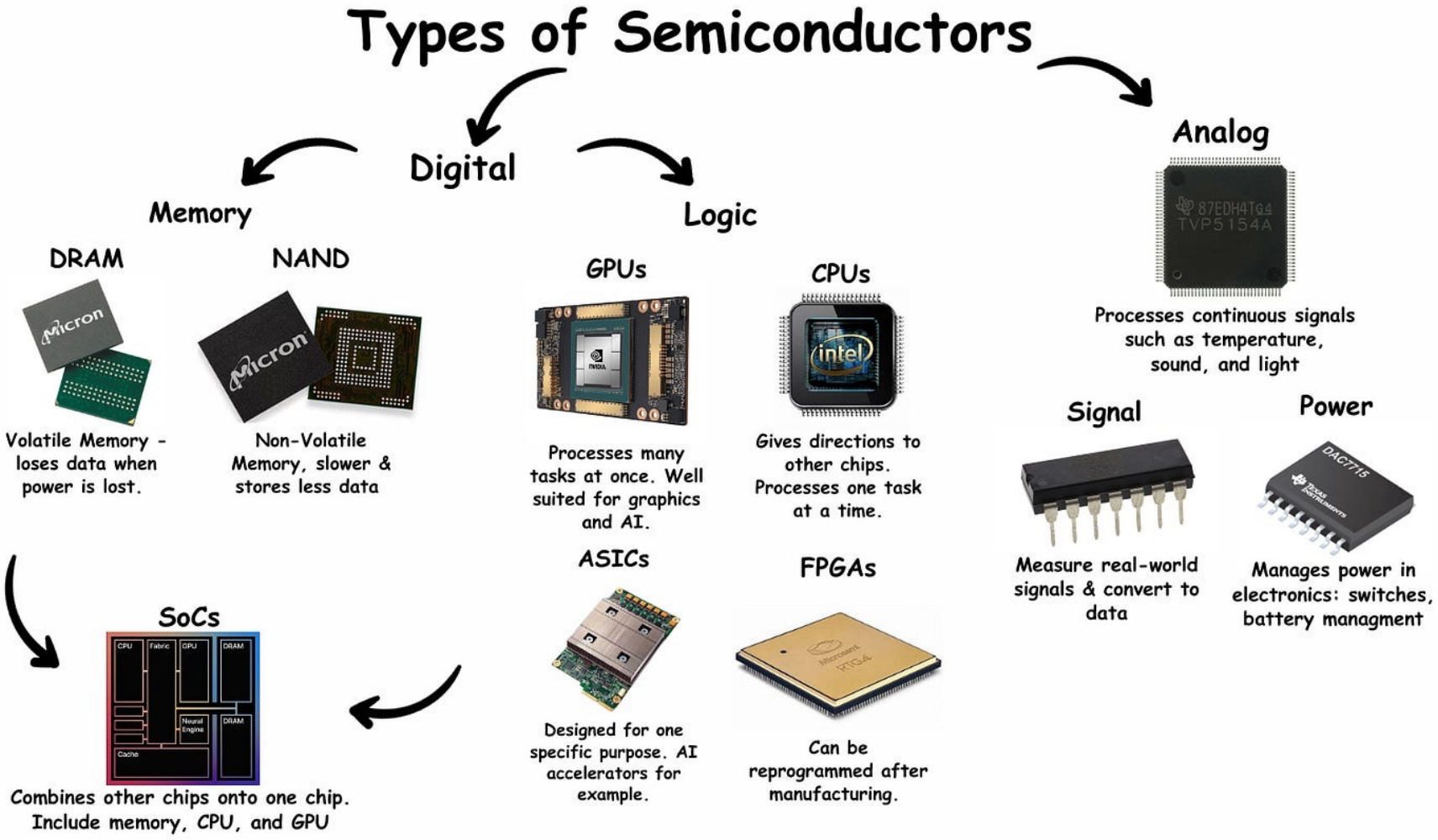
Course Description

The course of “Introduction to Solid-State Electronic Devices” (固態電子元件導論) is a foundational course designed for undergraduate students who wish to acquire a comprehensive understanding of semiconductor devices, including their fundamental characteristics, mechanisms, and underlying physics. In this course, students will learn important topics such as semiconductor band theory, carrier transportation and conduction in semiconductors, semiconductor junctions and diodes, MOS capacitors, MOSFETs, bipolar transistors, as well as VLSI memory technologies. Additionally, this course incorporates contemporary knowledge on semiconductor devices, ensuring students stay up to date with the latest advancements in the semiconductor field.

Semiconductor Applications

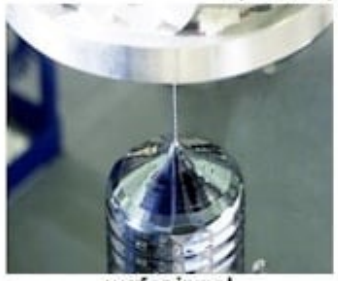


Semiconductor Products



Semiconductor Processes

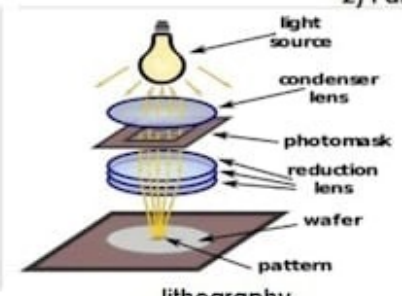
1) Wafer preparation



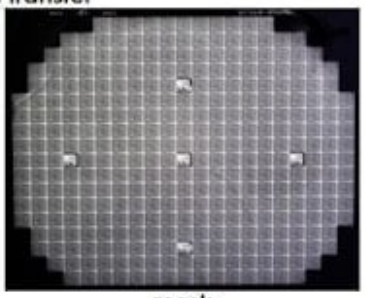
wafer ingot

wafer sliced, polished and cleaned

2) Pattern transfer

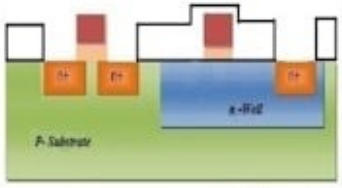


lithography

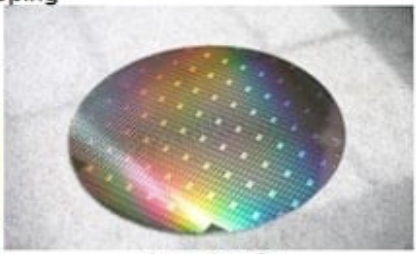


mask

3) Doping

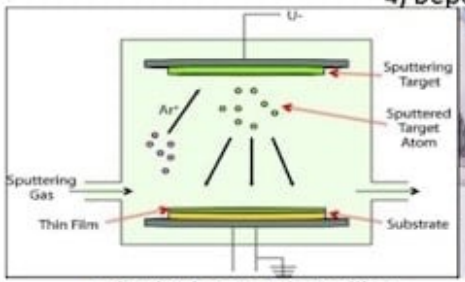


doped diagram



doped wafer

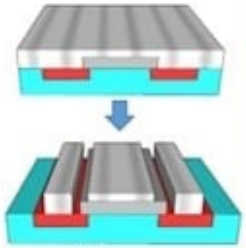
4) Deposition



physical vapor deposition

metal deposition

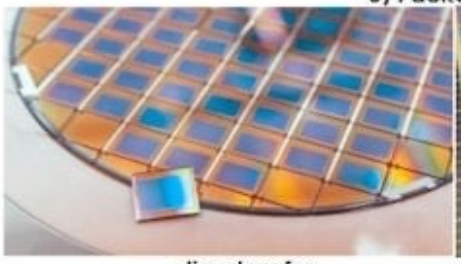
5) Etching



etching process

etched metal

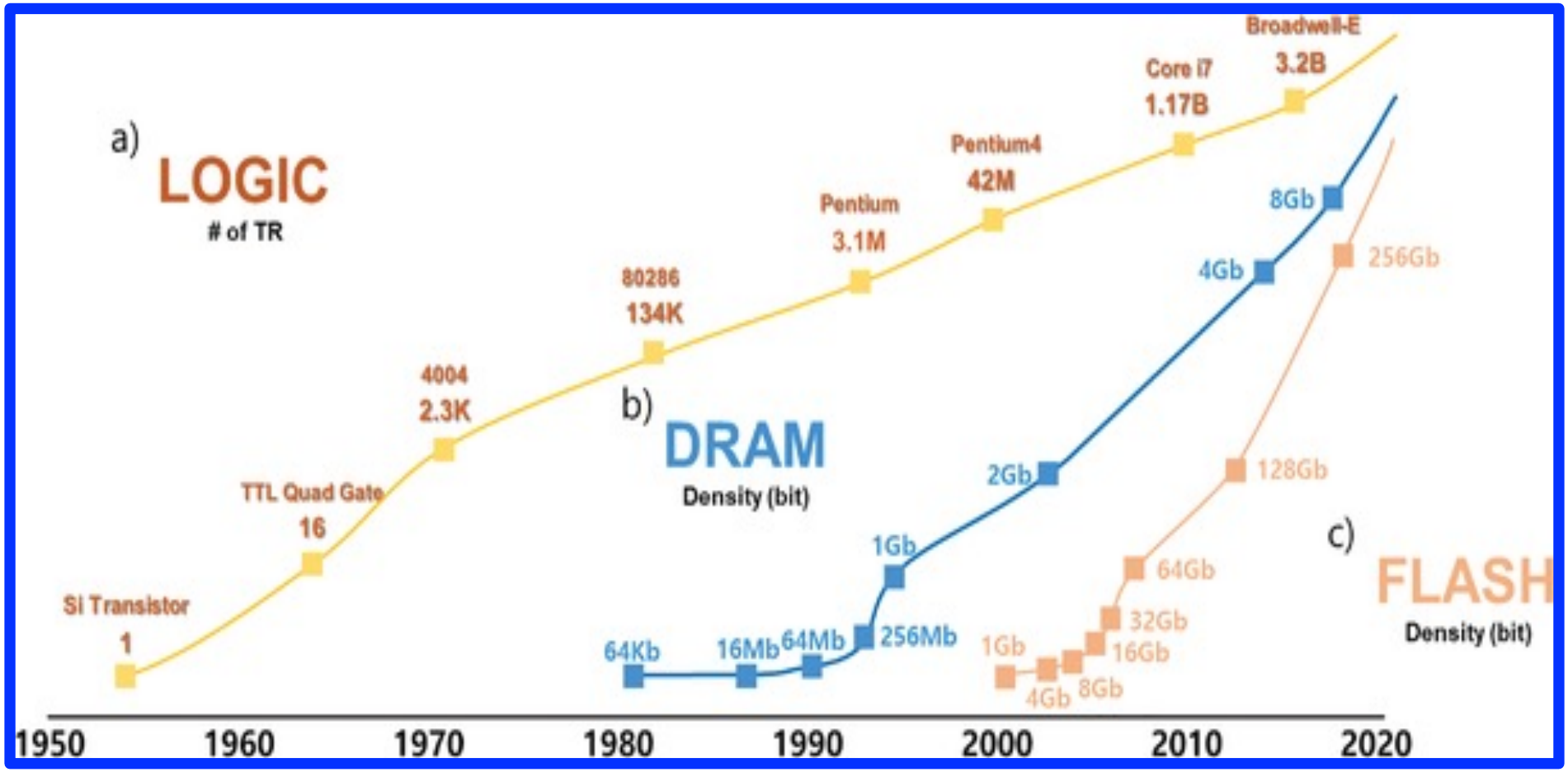
6) Packaging



diced wafer

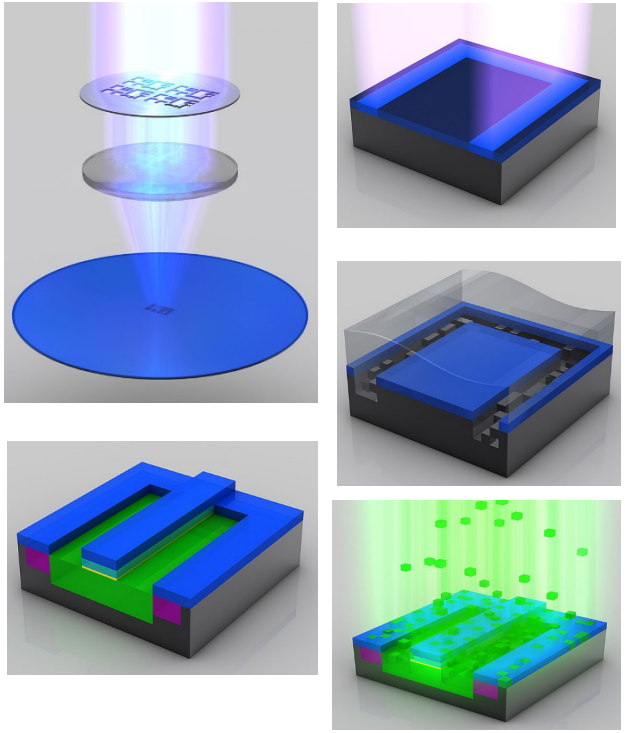
microchip

Technology Growth by Density



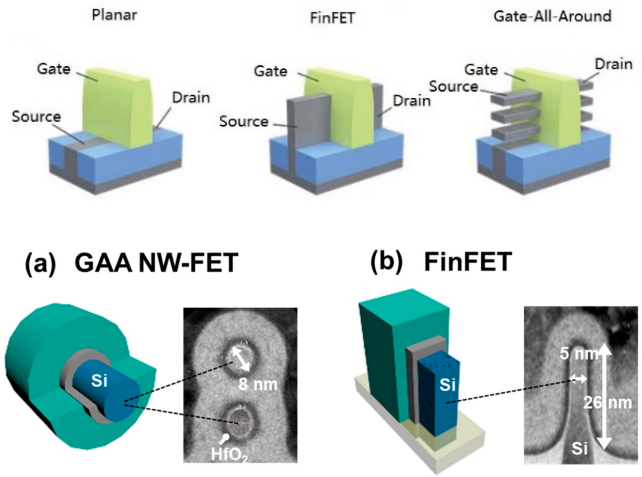
Expertise in Semiconductor

Manufacturing



Process and Module
(Lithography/Etch/Thin Film/Diffusion)
(製程與微電子工程)

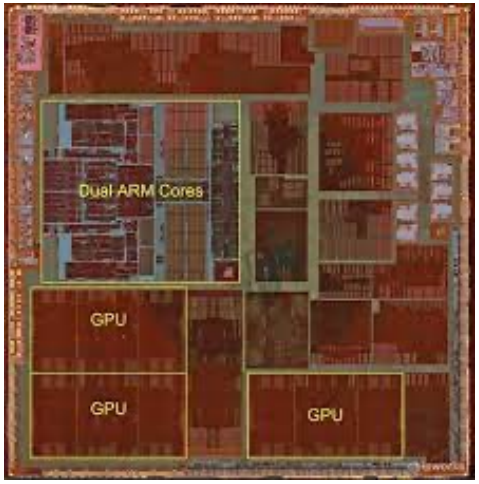
Technology



Solid-State Electronic Devices
(固態電子元件)

VLSI Device
(積體電路元件)

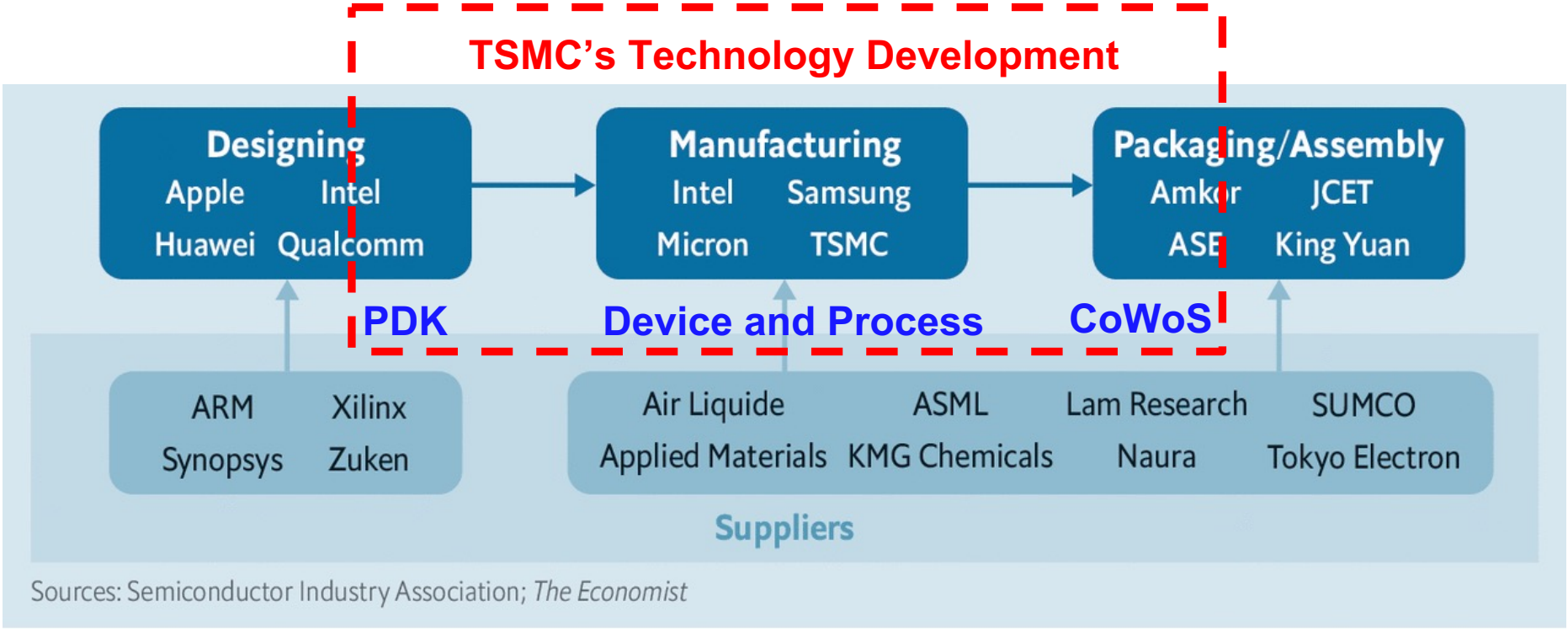
Chip Design



VLSI Circuit / Memory Design
(積體電路設計)

Digital/Analog Designs
(數位類比電路設計)

Semiconductor Industry Chain



The Economist

Syllabus in 16 Weeks

- Chap 1: Semiconductor Energy States and Bands (2W)
- Chap 2: Carrier Concentration and Conduction (2W)
- Chap 3: Semiconductor Junction and Diodes (2W)
- Midterm Exam (1W)
- Chap 4: MOS Capacitor and Planar MOSFET (2W)
- Chap 5: SOI and 3D MOSFET Technologies (2W)
- Chap 6: Bipolar Junction Transistor BJT (2W)
- Chap 7: Semiconductor Memory (2W / Optional)
- Final Exam (1W)

Grading Policy

- 40% for Quiz and Attendance
- 30% for Midterm Exam
- 30% for Final Exam

課程資訊 (Course Information)

科號 Course Number	11320ENE 513000	學分 Credit	3	人數限制 Class Size	40
中文名稱 Course Title	量子力學				
英文名稱 Course English Title	Quantum Mechanics				
任課教師 Instructor	洪勝富(HORNG, SHENG-FU) *more information*				
上課時間 Time	R7R8R9	上課教室 Room	DELTA台達208		

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Please respect the intellectual property rights, do not use illegal copies of textbooks.

此科目對應之系所課程規畫所欲培養之核心能力 Core capability to be cultivated by this course	■ 豐富的專業知識，以及工程運用的能力。 (35%) Comprehensive professional knowledge and the ability of utilizing the knowledge in engineering. (35%) □ 設計實驗、執行實驗、分析數據、以及歸納結果的能力。 The capability of designing experiments, executing experiments, analyzing data, and making conclusions. □ 策劃及執行專題研究、撰寫專業論文之能力。 The capability of planning research projects, conducting research projects, and writing professional papers. ■ 執行電子工程實務所需之理論、方法、技術、以及相關軟硬體工具之能力。 (35%) The theories, methods, techniques, and software and hardware tools needed for practicing electronics engineering. (35%) □ 電子工程系統、模組、元件或製程之設計能力。 The capability of designing electronic systems, modules, devices, and/or manufacturing processes. □ 團隊合作所需之組織、溝通、協調及跨領域整合的能力。 The skill for teamwork: organization, communication, negotiation and cross-discipline integration. ■ 發掘問題、分析問題、以及創新思考、獨立解決問題的能力。 (30%) The capability of finding problems, analyzing problems, independently solving problems, and creative thinking. (30%) □ 具備國際觀，並掌握國際電子科技及產業趨勢。 Being equipped with international scope and the ability to timely grasp the trend of international electronic technologies and industry. □ 具備專業倫理及社會責任 Full comprehension and execution of professional ethics and social responsibility. □ 具備領導管理及規劃之能力 Leadership in management and planning. □ 終身自我學習成長之能力 The capability of life-long self-learning and improvement.

課程簡述 (Brief course description)

This is a course on elementary quantum mechanics aiming for applications in solid-state physics and optoelectronic devices. Emphasis is put on the basic concepts and techniques, which will be applicable to solid state physics and optical properties of semiconductors. A heuristic approach will be adopted to introduce the basic concepts as well as the Schrodinger equation. We will soon move to one-dimensional bound state problems. Extended state problems in one dimension will also be explored. Algebraic operator method for simple harmonic oscillator will be covered. We will then introduce angular momentum operators and central potential problems. Time-independent and time- dependent perturbation methods will be included. Finally, identical particles with focus on equilibrium statistics will be introduced if time allows.

課程大綱 (Syllabus)

Course keywords:
quantum mechanics, solid state physics, optical properties, semiconductor, optoelectronic devices

一、課程說明(Course Description)

This is a course on elementary quantum mechanics aiming for applications in solid-state physics and optoelectronic devices. Emphasis is put on the basic concepts and techniques, which will be applicable to solid state physics and optical properties of semiconductors. A heuristic approach will be adopted to introduce the basic concepts as well as the Schrodinger equation. We will soon move to one-dimensional bound state problems. Extended state problems in one dimension will also be explored. Algebraic operator method for simple harmonic oscillator will be covered. We will then introduce angular momentum operators and central potential problems. Time-independent and time-dependent perturbation methods will be included. Finally, identical particles with focus on equilibrium statistics will be introduced if time allows.

二、指定用書(Text Books)
Handouts and homeworks will be distributed.

三、參考書籍(References)

1. A. Yariv, An introduction to theory and applications of quantum mechanics, New York
: Wiley.
2. A.P. French and Edwin F. Taylor, An Introduction to Quantum Physics, Norton & Company
3. David A.B. Miller, Quantum Mechanics for Scientists and Engineers, Cambridge University Press
4. Bernard Diu, Franck Laloe, and Claude Cohen-Tannoudji, Quantum Mechanics, Vol. 1 and
2, New York: Wiley.

四、教學方式(Teaching Method)
Lecturing with powerpoints.

五、教學進度(Syllabus)

1. history and dilemmas of classical physics in early nineteen century
2. a heuristic introduction to basic concepts in quantum physics
3. one-dimensional bound state problems
4. algebraic method for simple harmonic oscillator
5. one-dimensional scattering problems
6. angular momentum operator and central potential problems
7. time-independent perturbation method
8. time-dependent perturbation method and Fermi golden rule
9. identical particles and Boson/Fermion statistics

六、成績考核(Evaluation)

1. 作業(30%) 2. 考試 (2x35%)