CHE 4940 Fundamentals of Optoelectronic Materials and Devices
(光電材料與元件基礎 2 學分)

課程說明:

教育化工系的同學，使認識光電材料與光電元件的基礎及其製程，
俾便未來運用化學工程技術在這些相關的產業之中。
內容主要分為三大部分: 光電材料與元件基本原理, 無機光電材料與元件、有機光電材料與元件。

任課教師:

段興宇教授 (ext: 42509, hytuan@che.nthu.edu.tw, Room 311)

Prof. Masaki Horie (ext: 33628, mhorie@mx.nthu.edu.tw, Room 510)

教學進度：
I. 光電材料與元件基本原理: 段興宇教授

	授課內容
第1週 2/20	Class description
第2週 2/27	Semiconductor fundamentals
第3週 3/6	Principle of optoelectronic devices(I)
第4週 3/13	Principle of optoelectronic devices (II)
第5週 3/20	Principle of semiconductor-based solar cells
第6週 3/27	Integrated circuit (IC) manufacturing processes
第7週 4/3	Spring break
第8週 4/10	Chemical vapor deposition (CVD)
第9週 4/17	Invited speaker
第10週 4/24	Midterm

II有機光電材料與元件 Prof. Masaki Horie

	授課內容 (course content)
第11週 5/1	Introduction of organic electronics
第12週 5/8	Organic photovoltaic devices
第13週 5/15	Organic field effect transistors
第14週 5/22	Liquid crystal displays and organic light emitting diodes
第15週 5/29	Organic materials for energy storage (capacitor, battery, and fuel cell)
第16週 6/5	Molecular machines and devices
第17週	Final exam

成績評定

- Part I. 期中考, 50%.
- Part II期末考, 50%.

教學方式

Lectures (power point presentations)

Some information

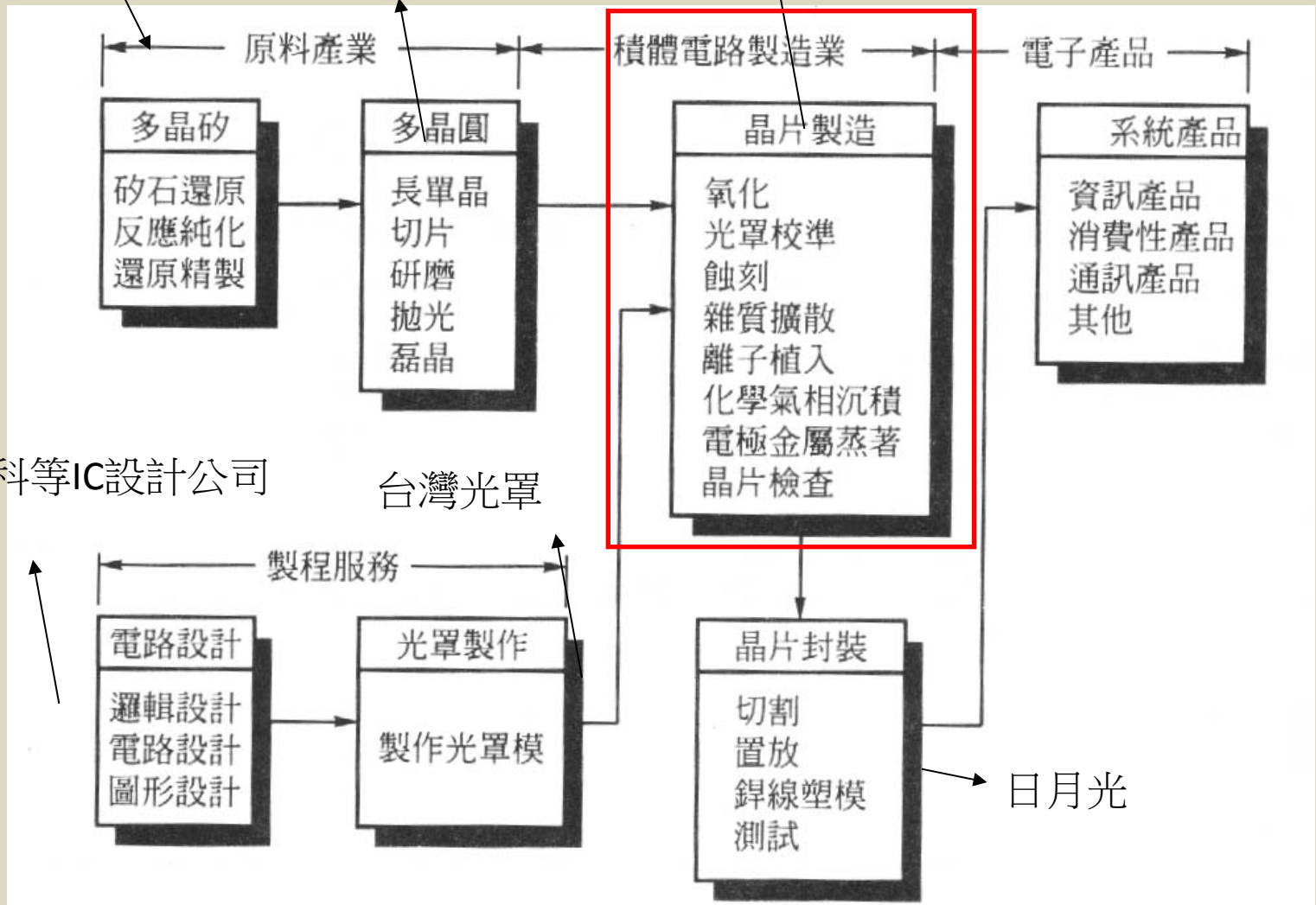
1. 投影片PDF檔下載：http://mx.nthu.edu.tw/~hytuan/
2. 助教：陳秋伶, s9932829@m99.nthu.edu.tw

Overview of Integrated Circuits (IC) industry in Taiwan

向外國購買

中美晶、綠能

台積電（世界第一）、聯電、漢磊



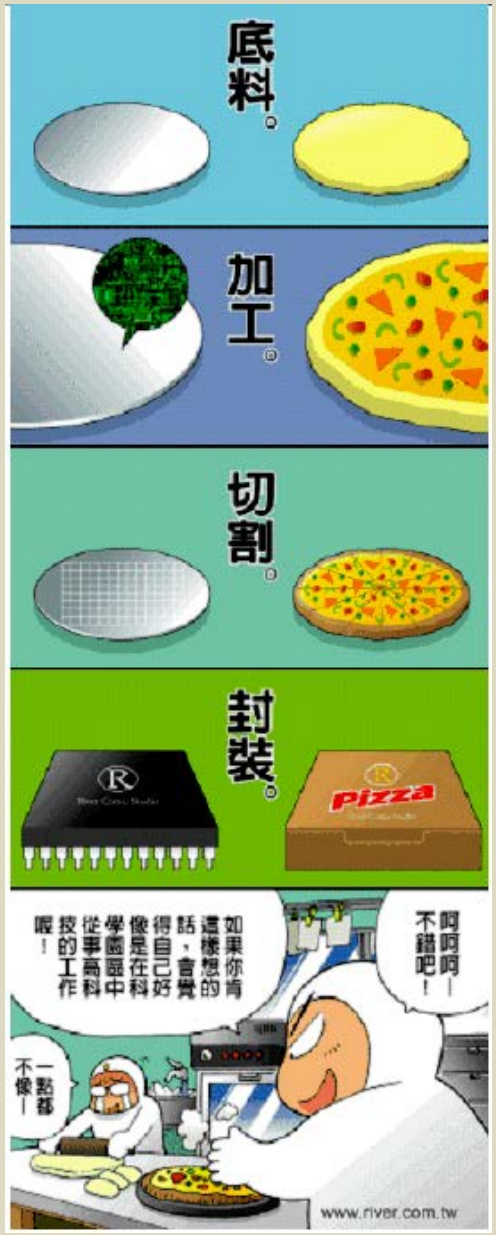
聯發科等IC設計公司

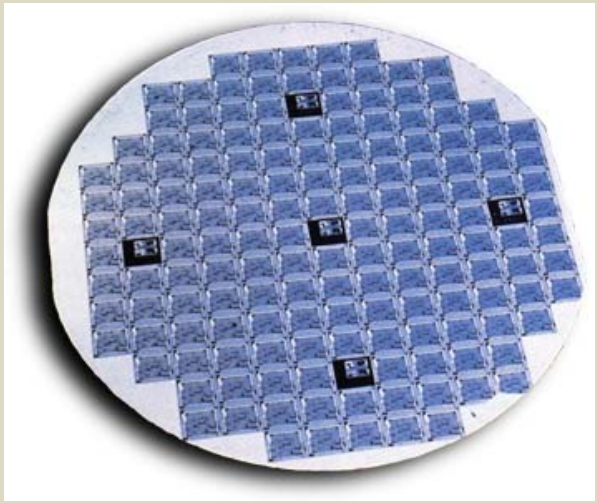
台灣光罩

日月光

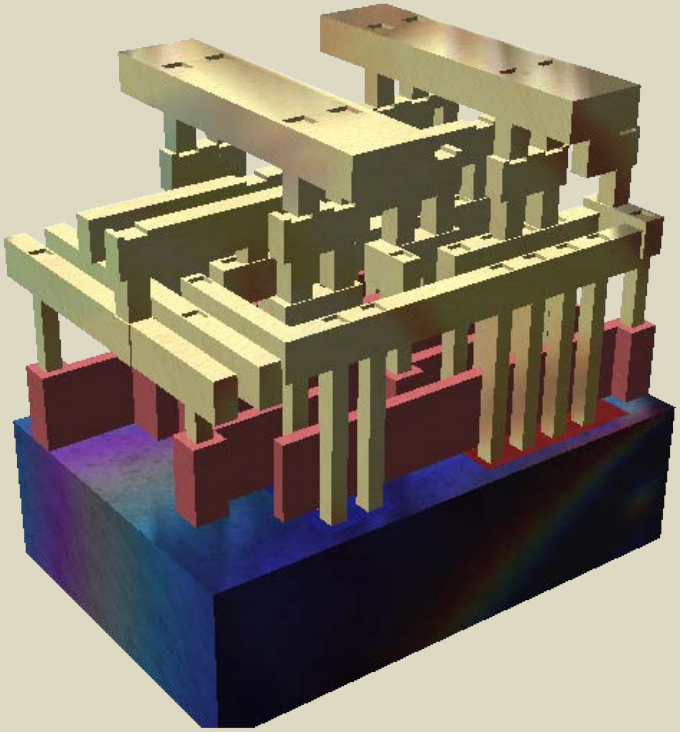
圖 1.2　積體電路工業體系

Pizza vs microchip fabrication





Integrated circuits (ICs)



- Combination of transistors, diodes, capacitors in a chip
- Ultra large scale integration (ULSI) >1,000,000 components per chips
- Morre's law: the number of transistors on a chip were doubling every 18 months
- Intel four core Itanium CPU- Tukwila has over 2 billion transistors on a chip

Courtesy of wiki

Periodic Table of the Elements

Note: The subgroup numbers 1-18 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

Si, Si, Si, why Silicon???

表 1.1 鍺、矽、砷化鎵的基本性質之比較

性質	Ge	Si	GaAs
Atoms/cm³	4.42×10^{22}	5.0×10^{22}	2.21×10^{22}
原子或分子重	72.6	28.08	144.63
密度(g/cm³)	5.32	2.33	5.32
晶體結構	Diamond	Diamond	Zinc blende
熔點(℃)	937	1412	1238
介電常數	16	11.8	10.9
有效能階密度			
導帶 N_c (cm^{-3})	1.04×10^{19}	2.8×10^{19}	4.7×10^{17}
價帶 N_v (cm^{-3})	6.1×10^{18}	1.04×10^{19}	7.0×10^{18}
電子親和力(V)	4.13	4.01	4.07
能隙(eV)	0.68	1.12	1.43
本質載子密度 n_i (cm^{-3})	2.5×10^{13}	1.5×10^{10}	1.79×10^{6}
晶格常數(Å)	5.658	5.431	5.654
有效質量			
電子	$m_n=0.22m$，$m_n^*=0.12m$	$m_n=0.22m$，$m_n^*=0.12m$	0.068m
電洞	$m_h=0.31m$，$m_h^*=0.23m$	$m_h=0.56m$，$m_h^*=0.38m$	0.56m
移動率(mobility)			
電子(cm^2/V-s)	3900	1350	8600
電洞(cm^2/V-s)	1900	480	250
導熱係數(W/cm-0C)	0.6	1.5	0.8
比熱(J/g℃)	0.31	0.7	0.35
線性熱膨脹係數($℃^{-1}$)	5.8×10^{-6}	2.6×10^{-6}	6.86×10^{-6}
少數載子生命週期(sec)	10^{-3}	2.5×1^{-3}	$\sim10^{-8}$

Silicon has smallest carrier mobility compared with Ge and GaAs.

Drawback of Ge

-Ge's device easily to leak at high temp.
-GeO2 is water soluble
-melting point of Ge is only 937 C

Drawback of GaAs

-hard to get high quality and large size wafer
-need additional procedures to form dielectic materials

Advantage of Si

-Cheap raw materials, e.g., rock, sand, second most abundant element on earth, appear as SiO2
- High melting point: 1415C
- stable silicon oxide (SiO2) as dielectric materials

Optoelectronic devices using semiconductors: Si、III-V、I-III-VI, many semiconductors are candidates

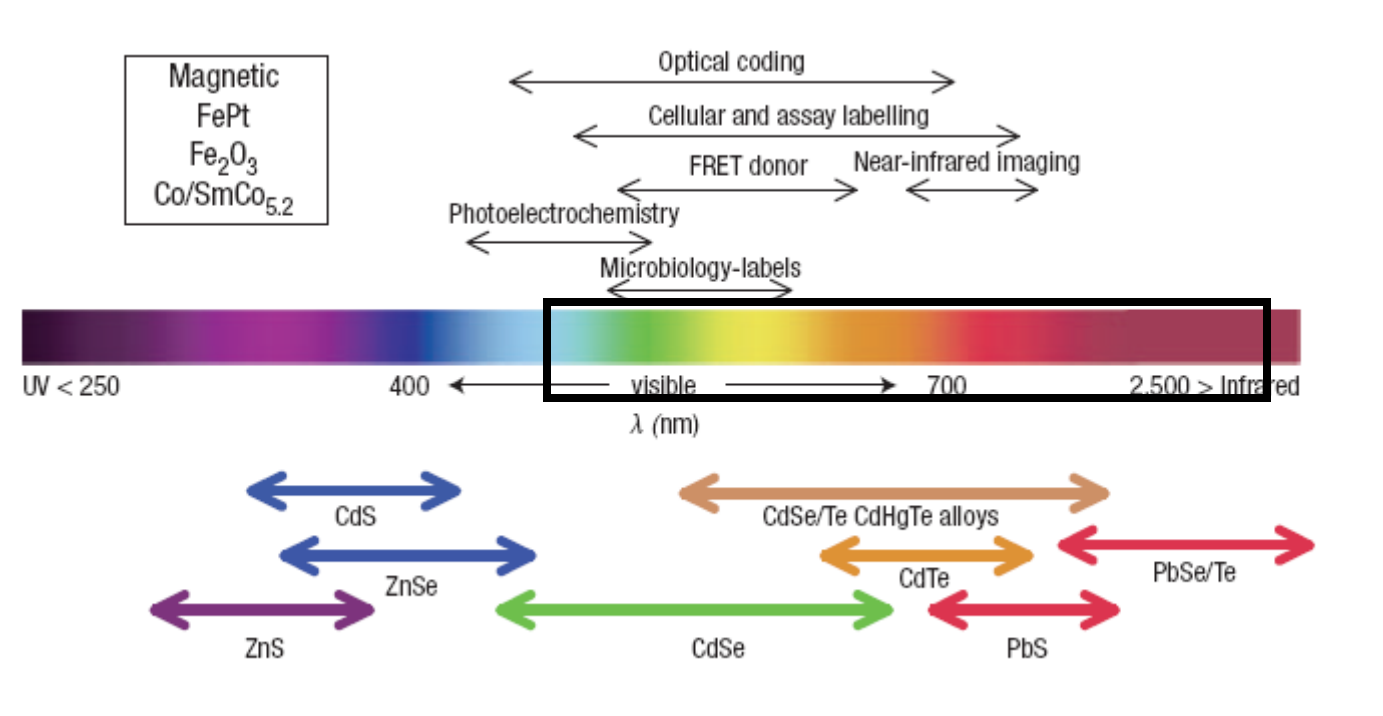
- LED (light emitting diodes)

- Laser

- Solar cell

- Photodetector

The band gap of semiconductor optoelectronic materials corresponding to a optical spectrum



E= hc/λ

E=1.24/ λ (eV)
When E: electron volts
λ:μm

-direct band gap materials
-Compound (II-VI, III-V, IV-VI) semiconductors

LED – basic manufacturing processes

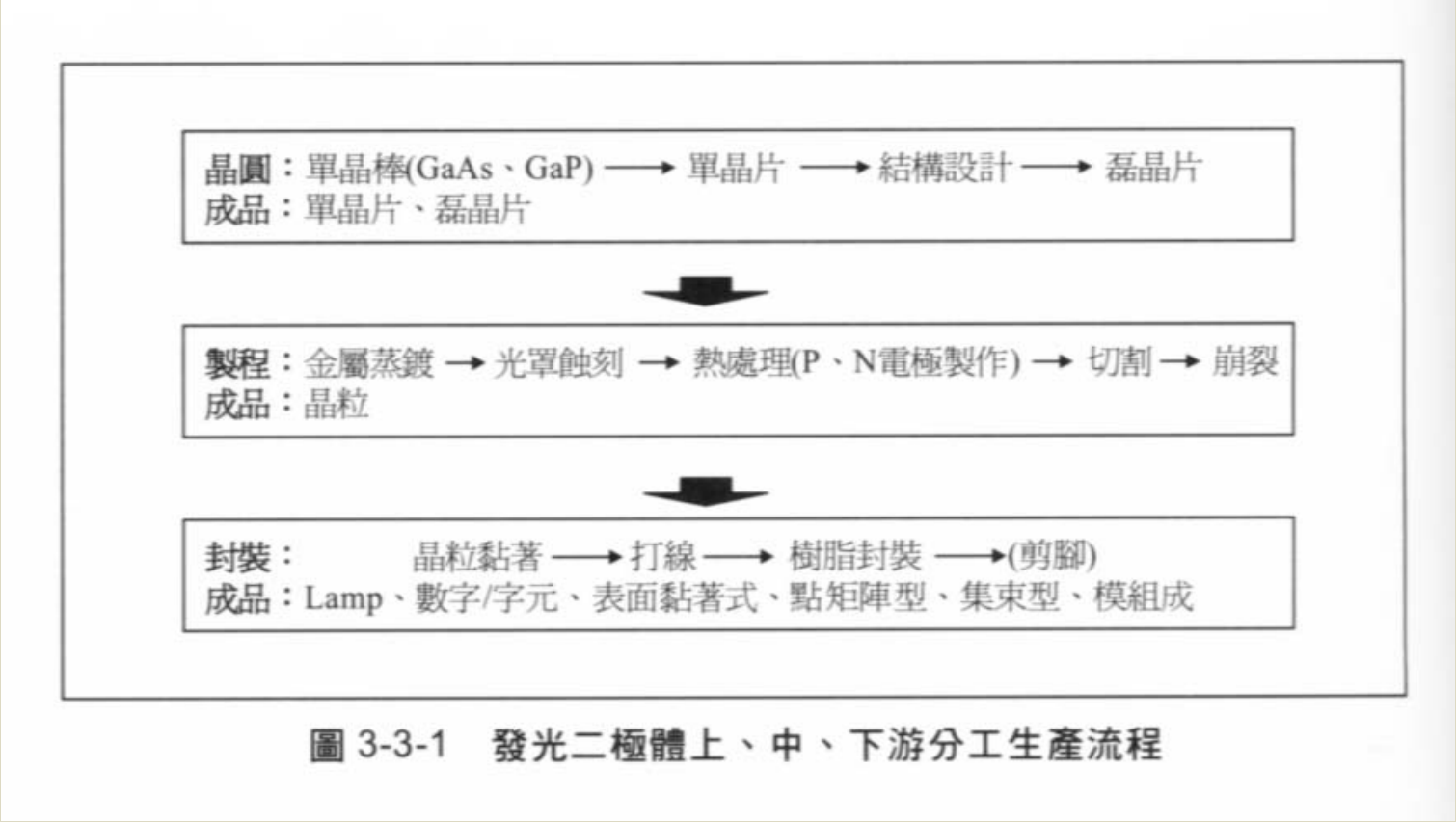


圖 3-3-1　發光二極體上、中、下游分工生產流程

經,3-76

Similar manufacturing process could be also applied to laser, solar cell industry

友達光電-國內最大的面板廠

國立清華大學化學工程所博士 92D

曾任友達光電總經理陳來助博士

本系的系友
你們的學長

工學院 Next Power 講座、學生獎學金捐款
(一年一百萬、為期五年)

晶元光電-國內LED第一大廠

EPISTAR corporation
晶元光電股份有限公司

國立清華大學工業化學系學士 80B
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晶元光電董事長兼總經理
李秉傑博士

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晶元光電講座、學生獎學金捐款（一年一百萬、為期五年）