

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

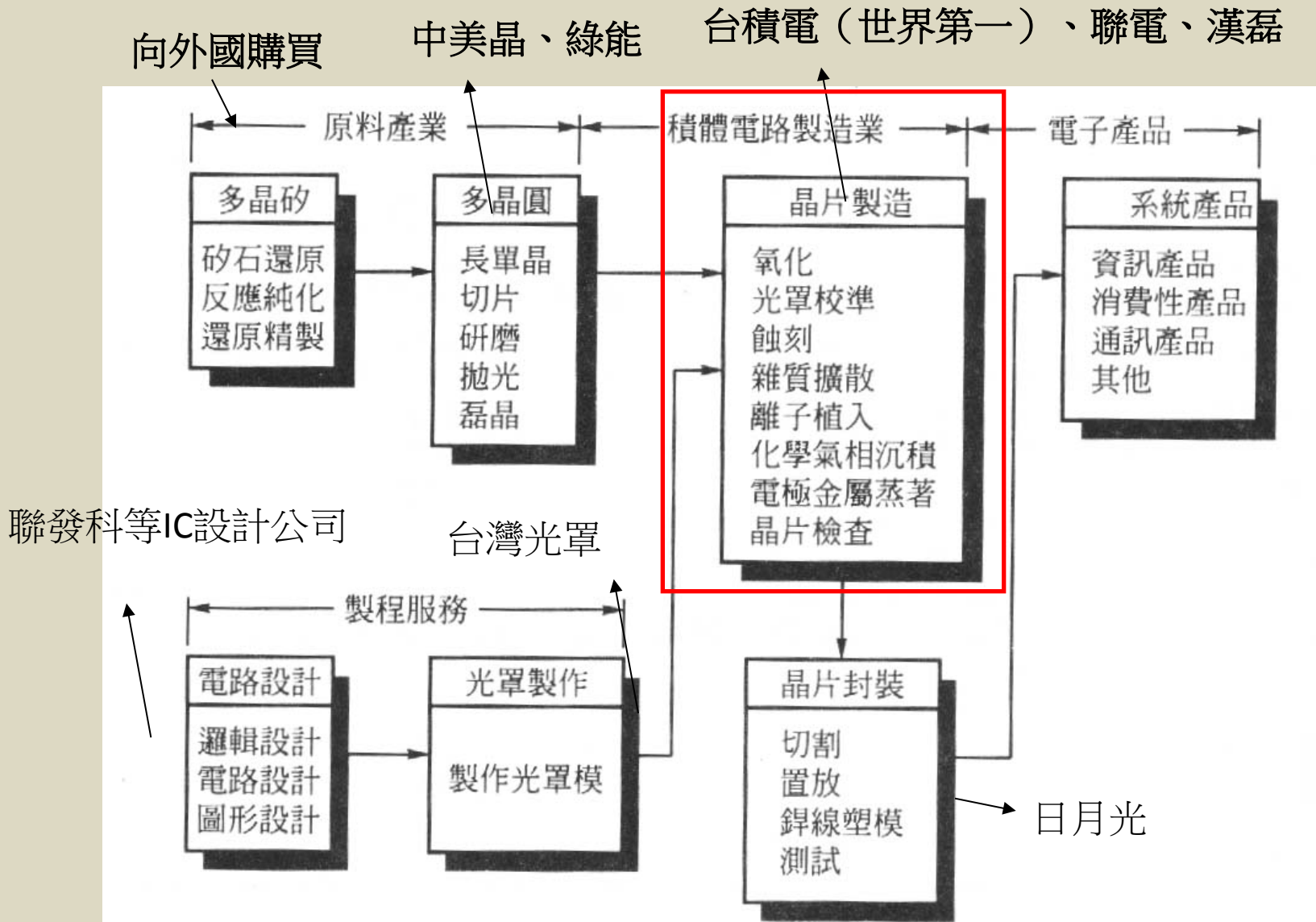
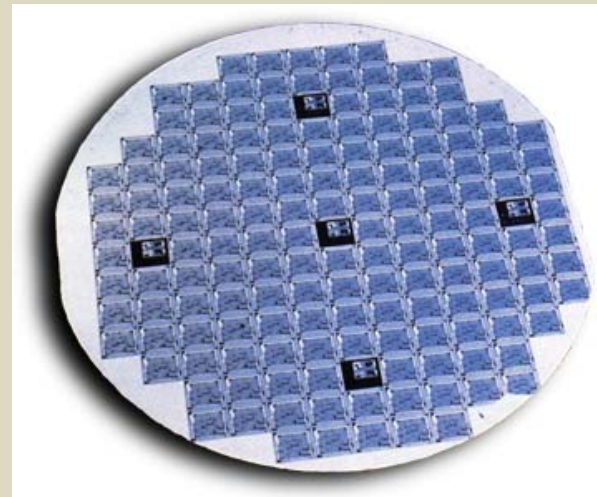
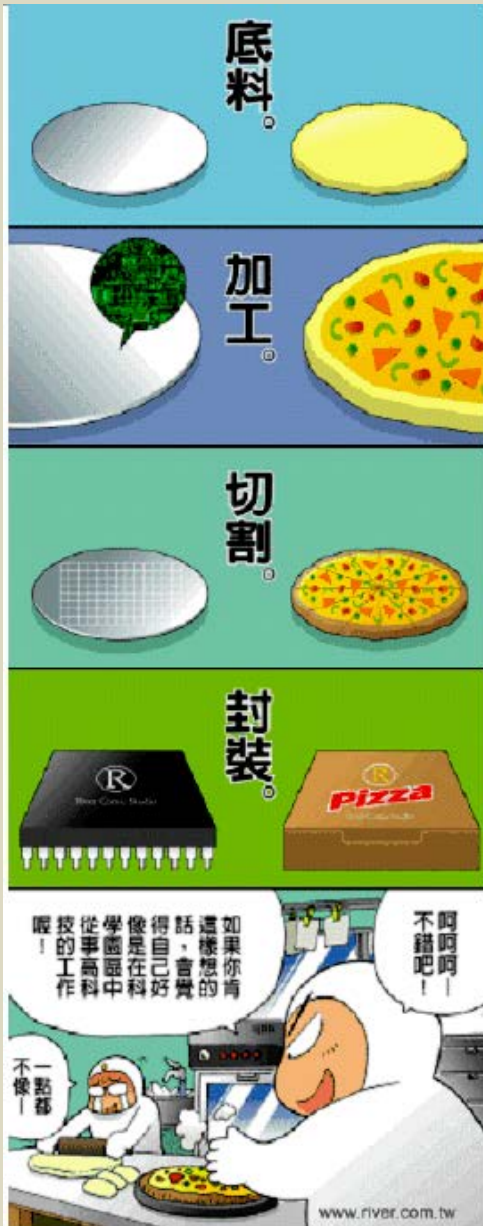
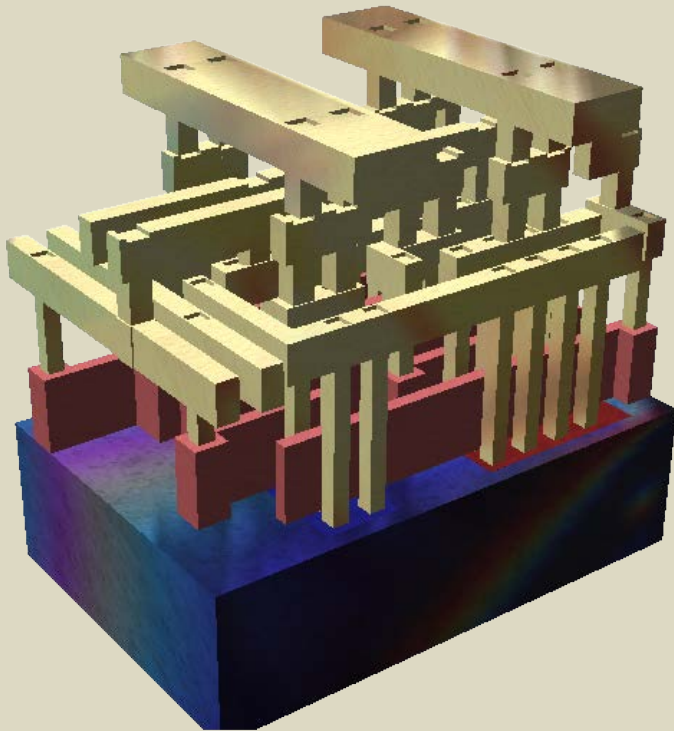


圖 1.2 積體電路工業體系

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

1	New Original												13	14	15	16	17	18																																																																																		
IA	IIA												IIIA	IVA	VA	VIA	VIIA	VIIIA																																																																																		
1 H Hydrogen 1.00794	2 He Helium 4.002602												5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797	11 Na Sodium 22.989770	12 Mg Magnesium 24.3050	3 Al Aluminum 26.981538	4 Si Silicon 28.0855	5 P Phosphorus 30.973761	6 S Sulfur 32.066	7 Cl Chlorine 35.453	8 Ar Argon 39.948	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.8457	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293	55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 to 71		72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)	87 Fr Francium (223)	88 Ra Radium (226)	89 to 103		104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium	118 Uuo Ununoctium

- Alkali metals
- Alkaline earth metals
- Transition metals
- Lanthanide series
- Actinide series
- Poor metals
- Nonmetals
- Noble gases
- C** Solid
- Br** Liquid
- H** Gas
- Tc** Synthetic

Atomic masses in parentheses are those of the most stable or common isotope.

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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.

57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium (227)	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

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/cm ³	4.42×10 ²²	5.0×10 ²²	2.21×10 ²³
原子或分子重	72.6	28.08	144.63
密度(g/cm ³)	5.32	2.33	5.32
晶體結構	Diamond	Diamond	Zinc blende
熔點(°C)	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 _e = 0.22m, m _e [*] = 0.12m	m _e = 0.22m, m _e [*] = 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°C)	0.31	0.7	0.35
線性熱膨脹係數(°C ⁻¹)	5.8×10 ⁻⁶	2.6×10 ⁻⁶	6.86×10 ⁻⁶
少數載子生命週期(sec)	10 ⁻³	2.5×10 ⁻³	~10 ⁻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 dielectric 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



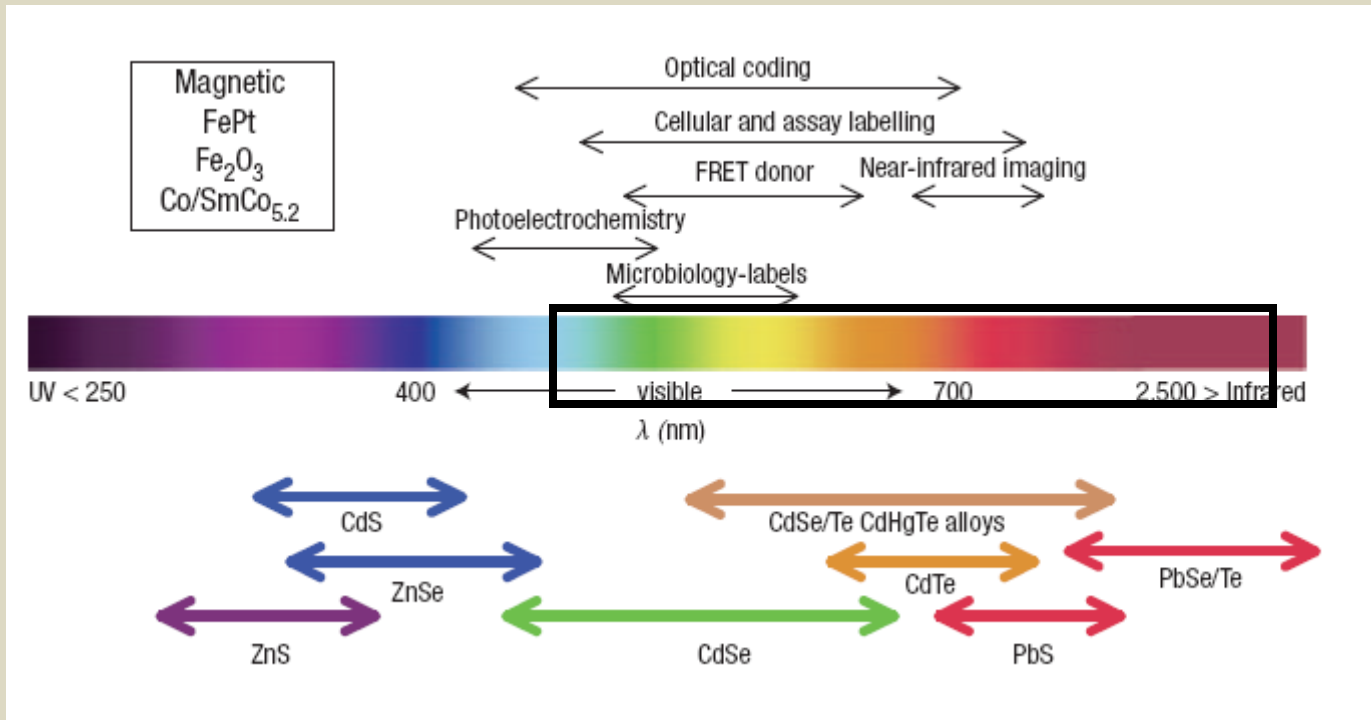
- Solar cell



- Photodetector



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



$$E = hc/\lambda$$

$$E = 1.24/\lambda \text{ (eV)}$$

When E: electron volts

λ : μm

-direct band gap materials

-Compound (II-VI, III-V, IV-VI) semiconductors

LED – basic manufacturing processes

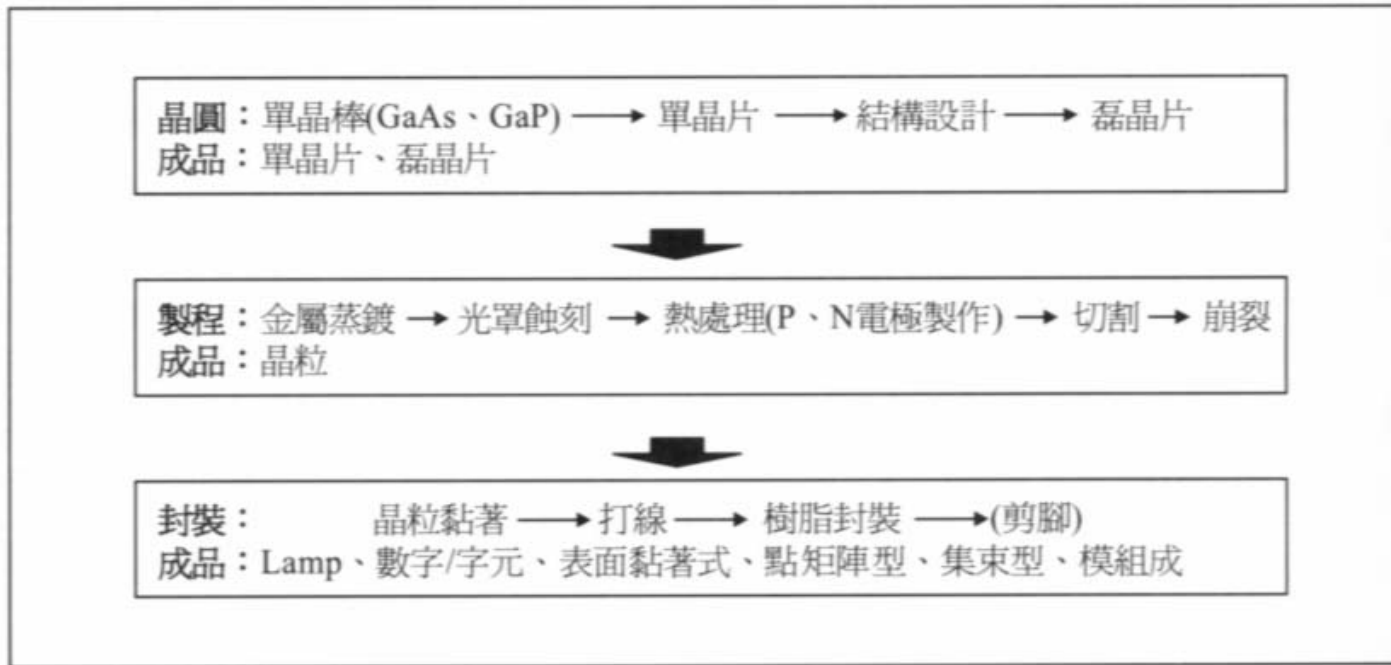


圖 3-3-1 發光二極體上、中、下游分工生產流程

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

友達光電-國內最大的面板廠

The logo for AUO (Auotronics Optoelectronics) is displayed in white text on a blue rectangular background.

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



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