第二章
IC製程之簡介

廠房支出

- 廠房價值很高，8吋廠值美金十億以上
- 潔淨室
- 儀器設備，通常 每件超過美金一百萬
- 物質，高純度，超高純度
- 設備
- 人員，訓練及給付

晶圓良率

$$Y_W = \frac{Wafers_{good}}{Wafers_{total}}$$

晶粒良率

$$Y_D = \frac{Dies_{good}}{Dies_{total}}$$

封裝良率

$$Y_C = \frac{Chips_{good}}{Chips_{total}}$$

整體產率

$$Y_T = Y_W \times Y_D \times Y_C$$

整體良率決定一個廠房是否能得到利益或虧損

生產廠房如何賺錢

- 支出
  - 晶圓 (8”)： ~$150/晶圓*
  - 製程： ~$1200 ($2/晶圓/步驟，600個步驟)
  - 封裝： ~$5/晶片
- 銷售
  - ~200 晶片/晶圓
  - ~$50/晶片 (低階的微處理器，2000年)

*Cost of wafer, chips per wafer, and price of chip varies, numbers here are choosing randomly based on general information.

生產廠房如何賺錢（虧錢）

支出	• **100%良率: 150+1200+1000 = $2350/晶圓** • 50%良率: 150+1200+500 = $1850/晶圓 • *0%良率: 150+1200 = $1350/晶圓*
銷售	• **100%良率: 200×50 = $10,000/晶圓** • 50%良率: 100×50 = $5,000/晶圓 • *0%良率: 0×50 = $0.00/晶圓*
邊際效益	• **100% 良率: 10000 – 2350 = $7650/晶圓** • 50%良率: 5000 – 1850 = $3150/晶圓 • *0%良率: 0 – 1350 = –$1350/晶圓*

問題

- 如果每一程序的良率皆爲99%，試問經600個製程程序之整體良率爲何？

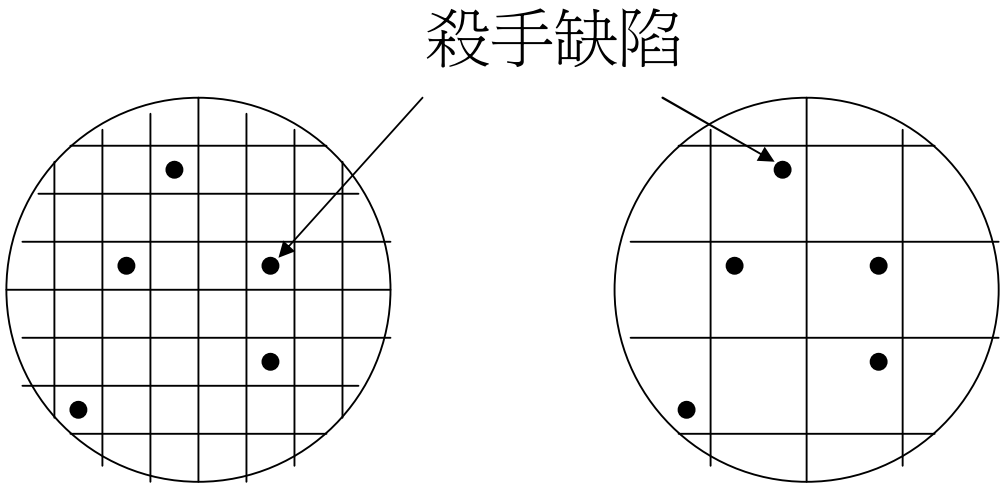
答案:

- $0.99^{600} = 0.24\%$

爲了使一程序在經濟考量上爲可實行的，試問每一步驟之良率需多高？

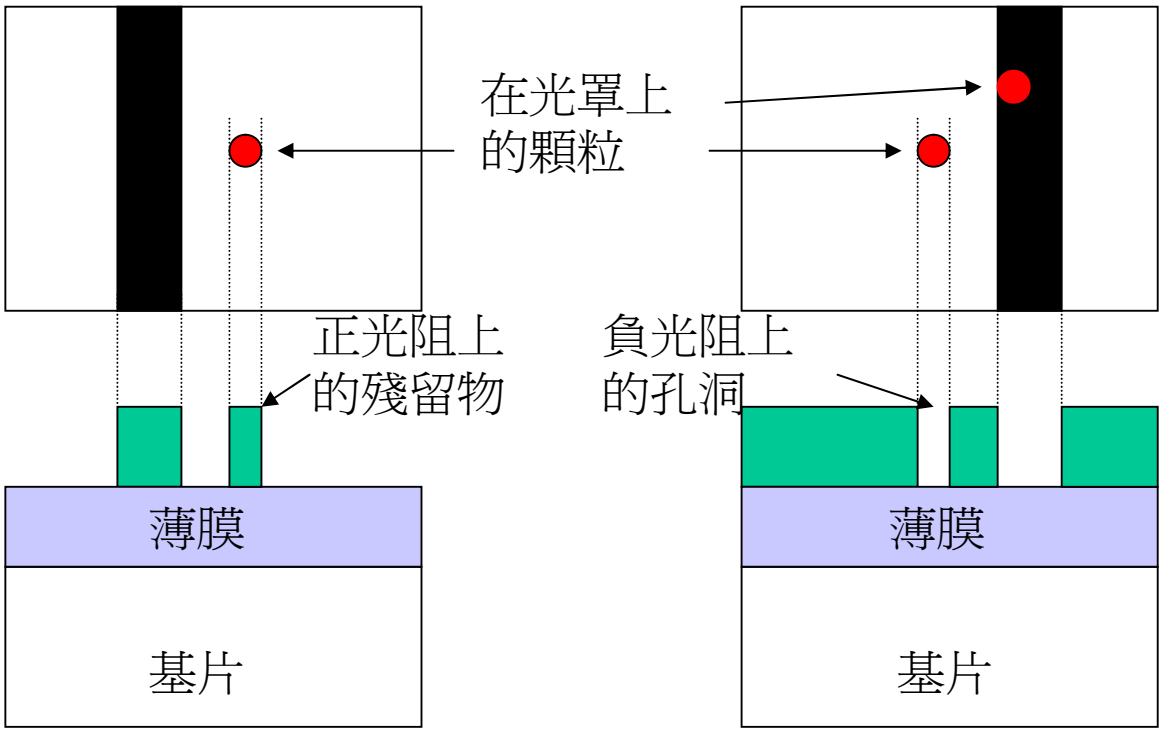
- $0.999^{600} = 54.8\%$
- $0.9999^{600} = 94.2\%$

粒子污染

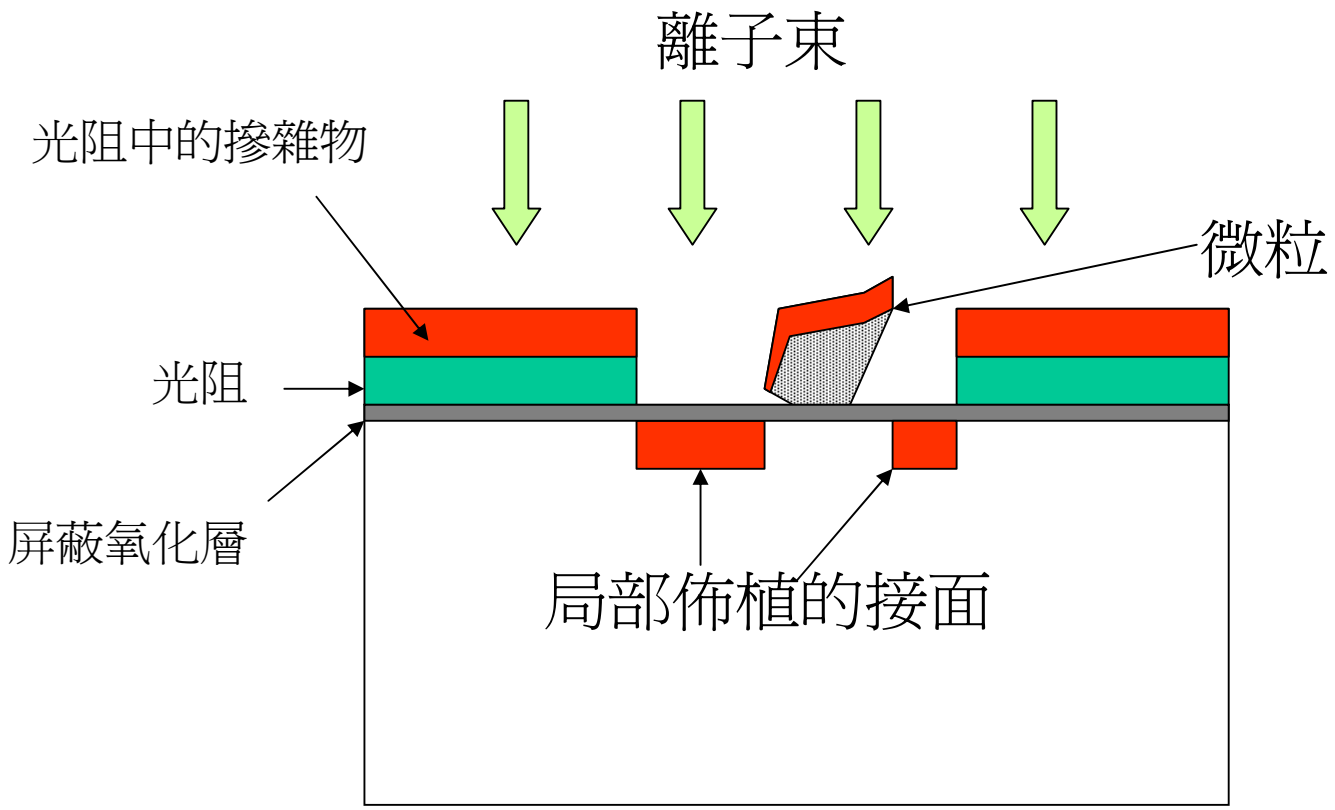


Y = 28/32 = 87.5%　　Y = 2/6 = 33.3%

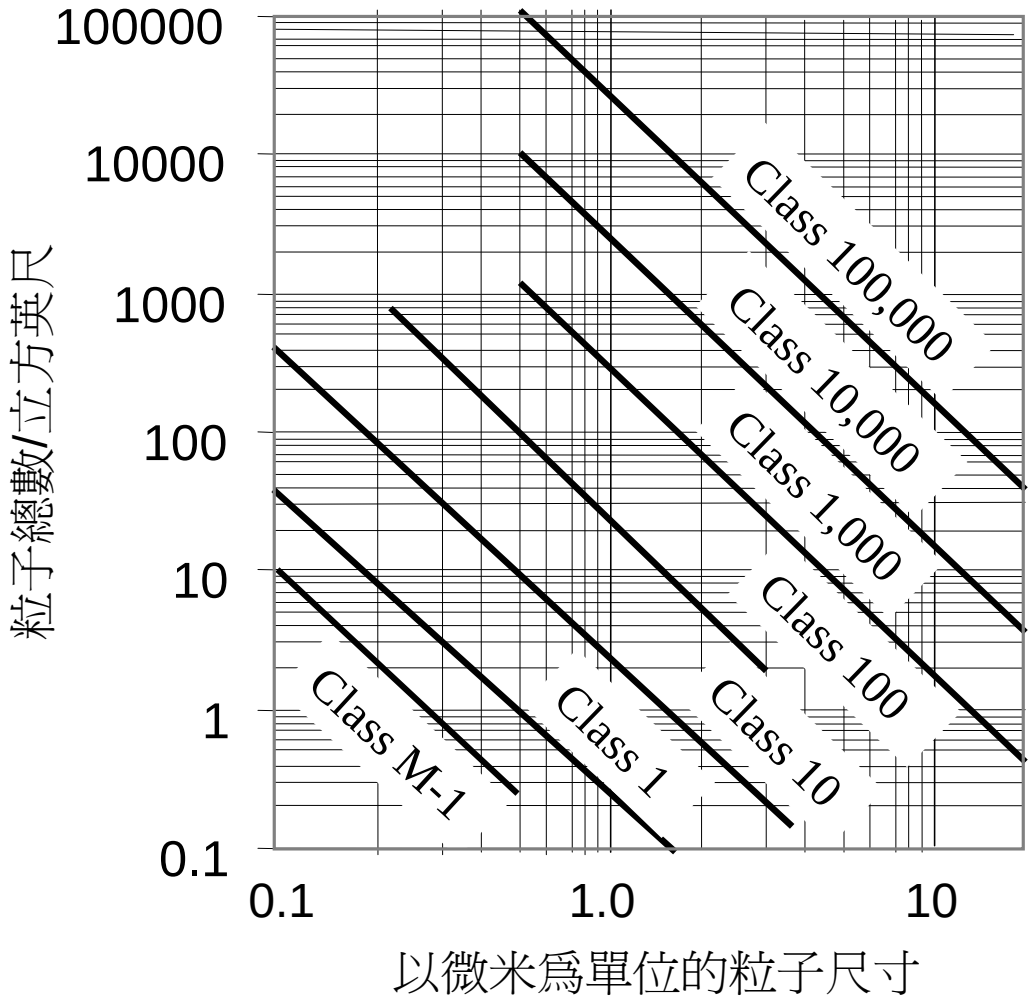
光罩上的粒子污染效應



粒子污染效應



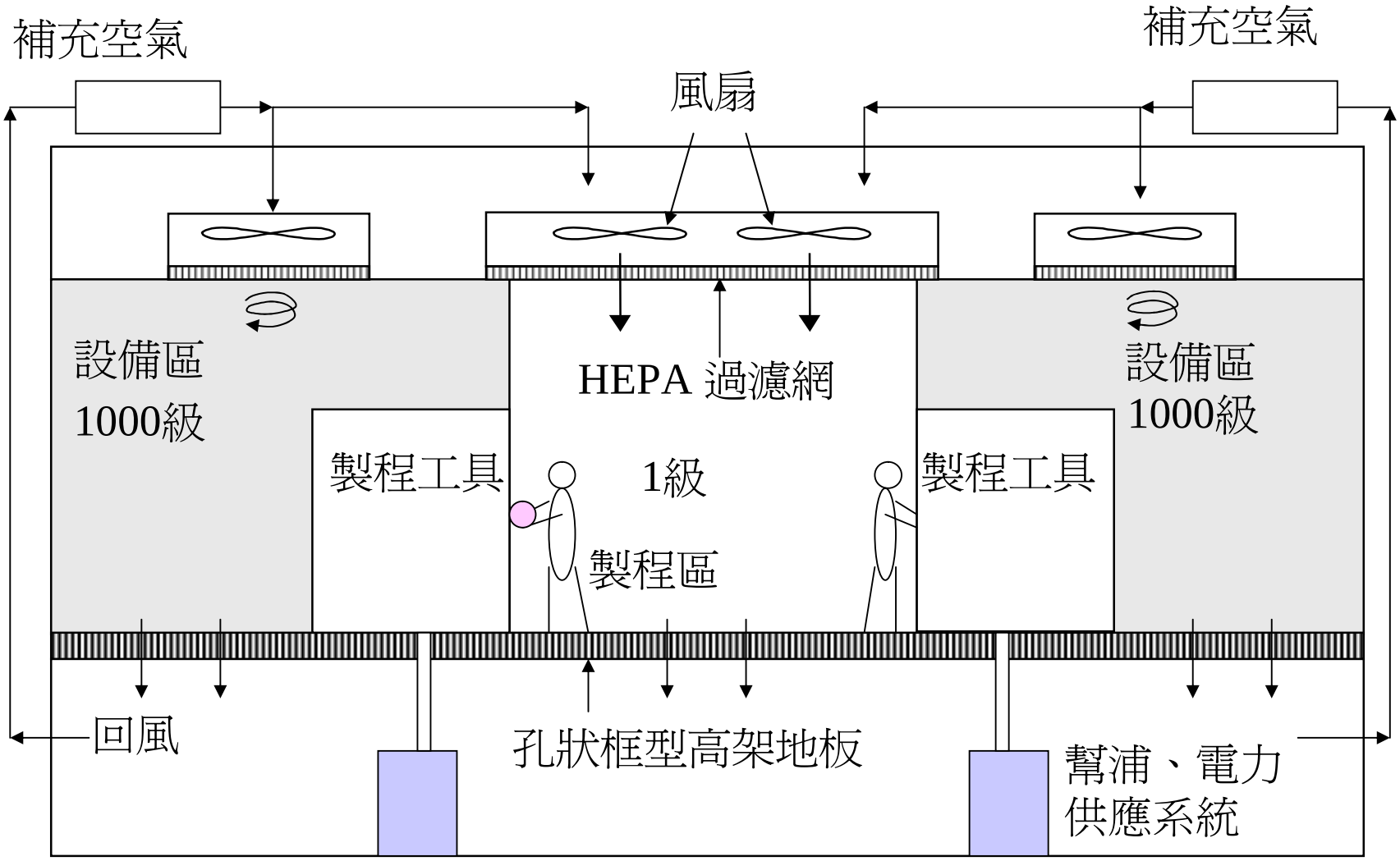
無塵室等級


100000
10000
1000
100
10
1
0.1
粒子總數/立方英尺
Class 100,000
Class 10,000
Class 1,000
Class 100
Class 10
Class 1
Class M-1
0.1
1.0
10
以微米爲單位的粒子尺寸

依聯邦標準209E定義所製定之空氣含微粒子的潔淨等級表

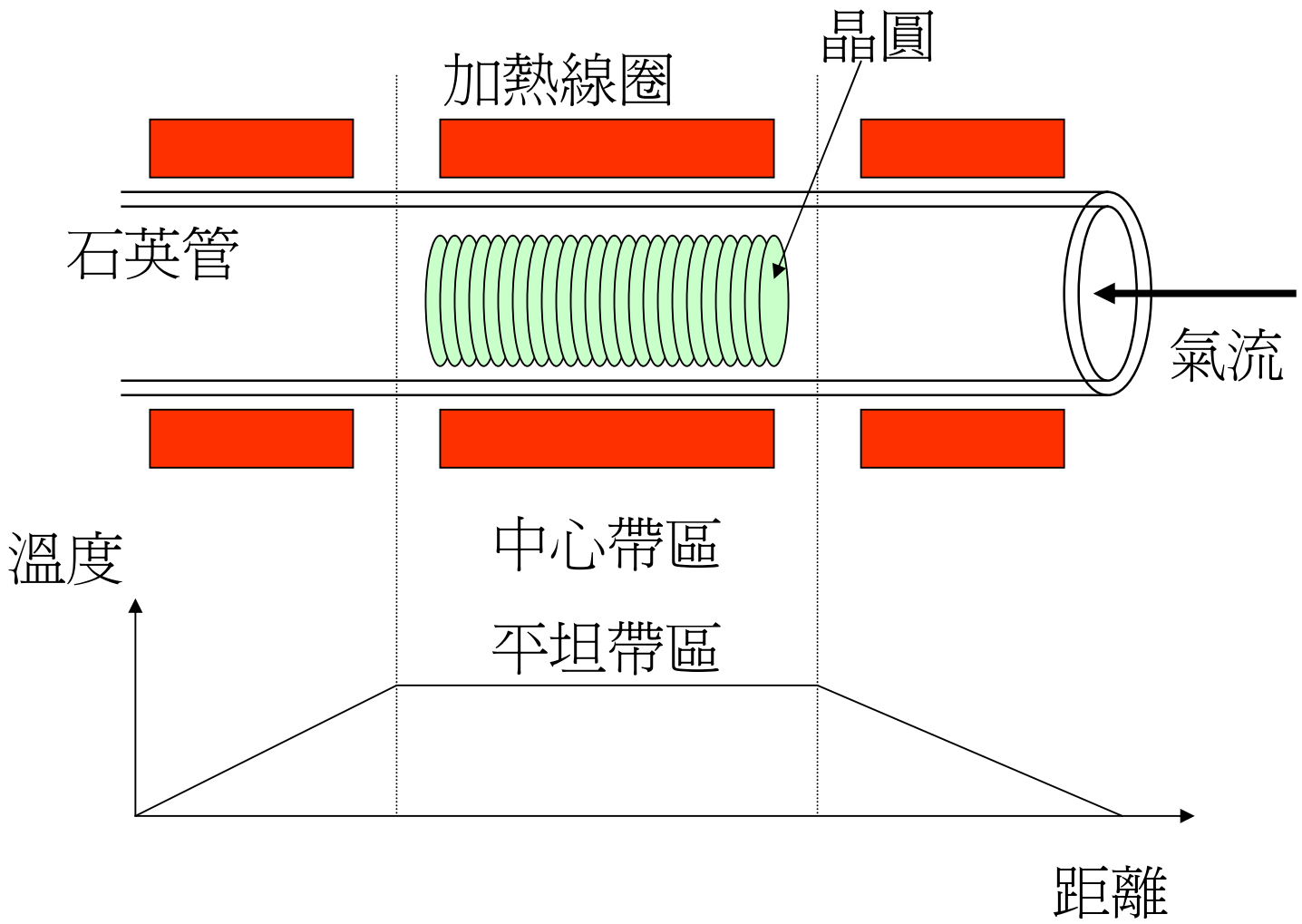
等級	粒子總數/立方英尺				
	0.1 μm	0.2 μm	0.3 μm	**0.5 μm**	5 μm
M-1	9.8	2.12	0.865	**0.28**	
1	35	7.5	3	**1**	
10	350	75	30	**10**	
100		750	300	**100**	
1000				**1000**	7
10000				**10000**	70

無塵室基本結構

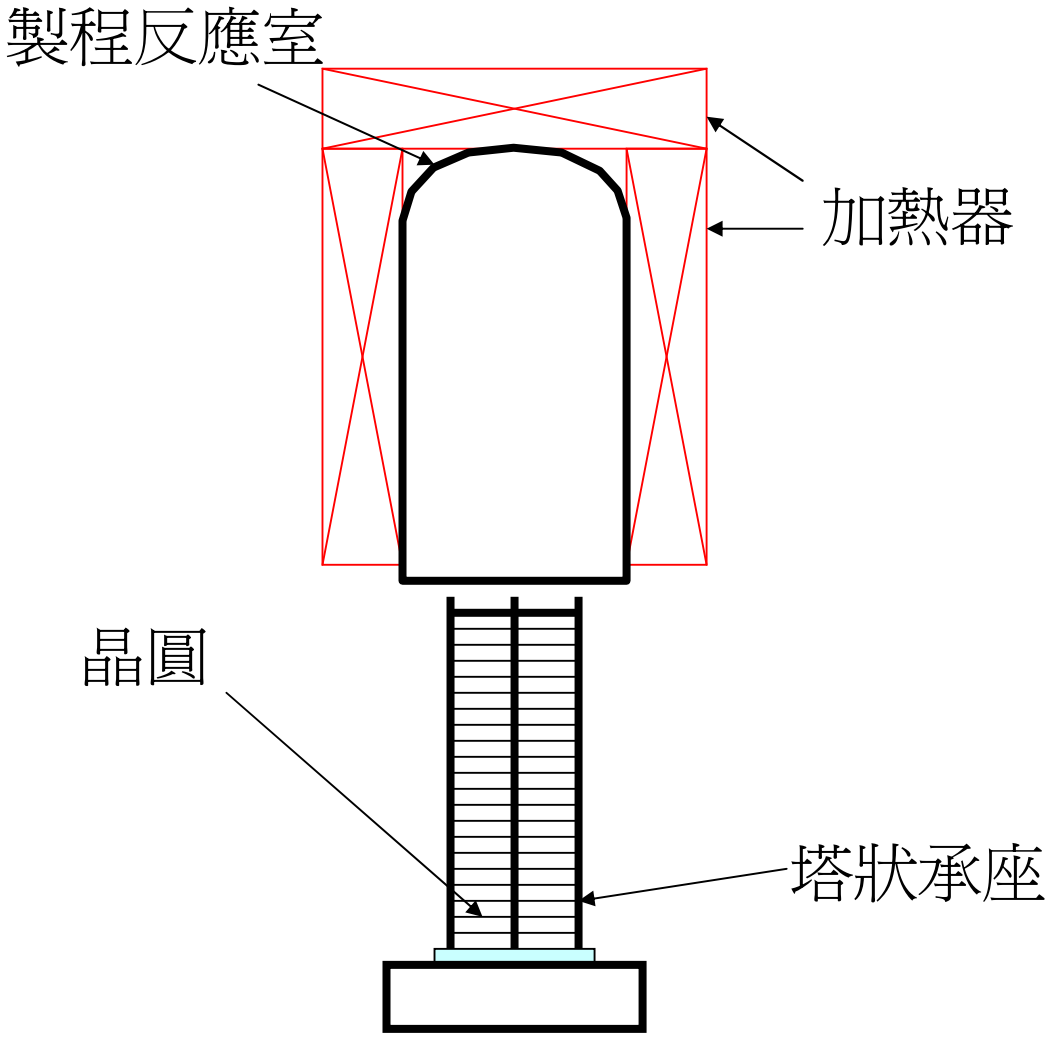


等級在Class 100 以上(10,1…)爲線性流;以下爲混亂流turbulent flow

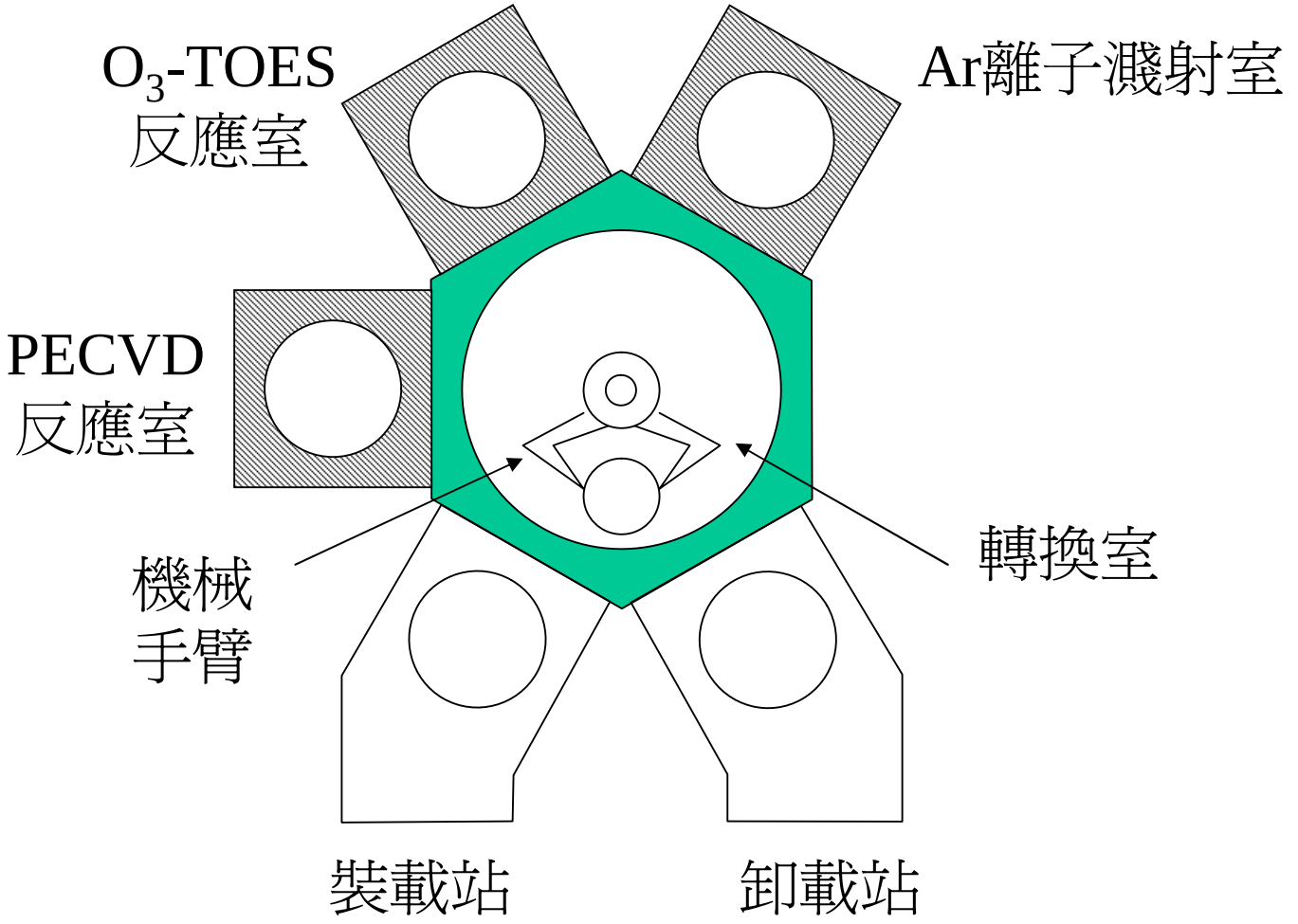
水平式爐管



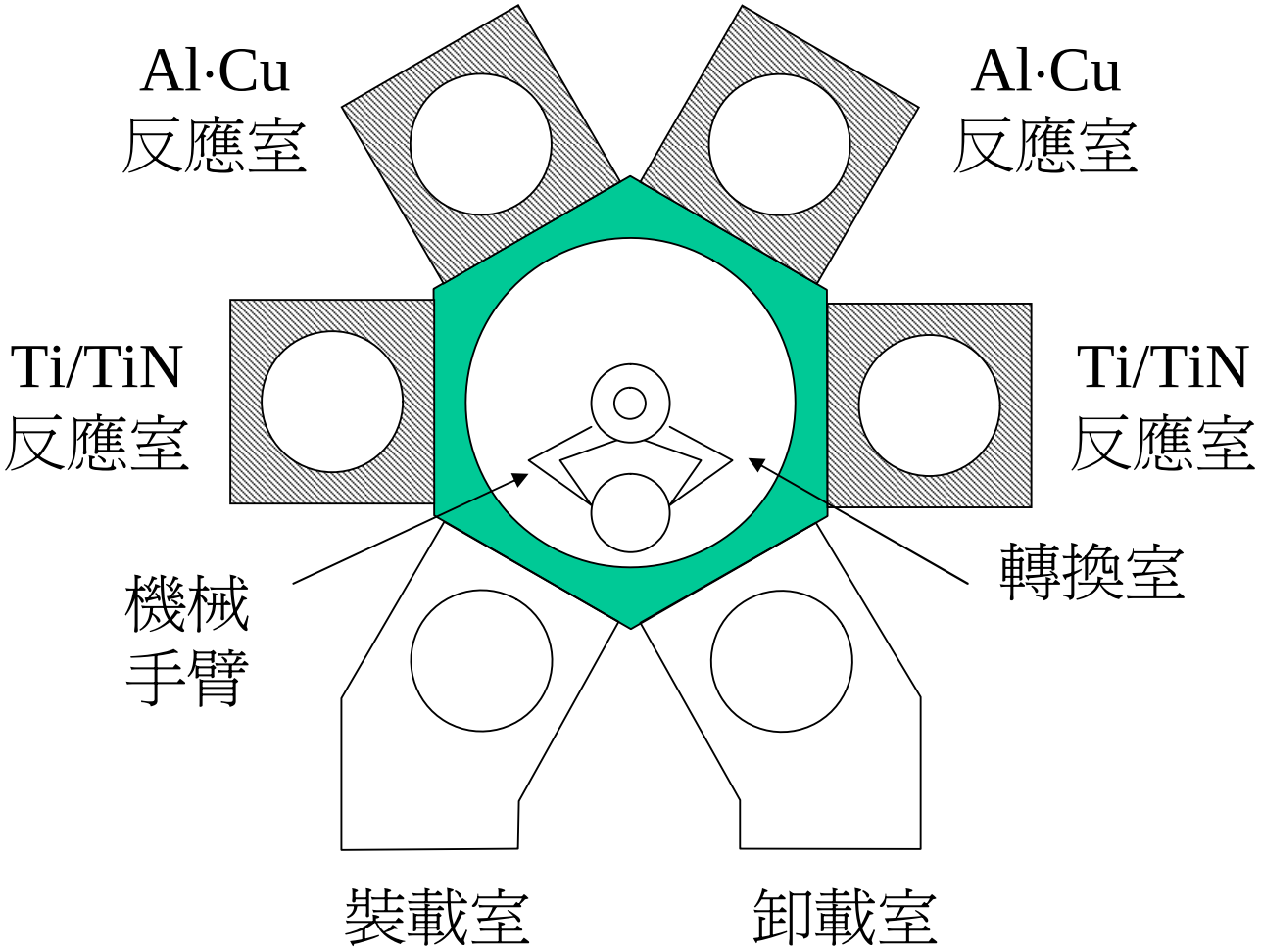
垂直式爐管



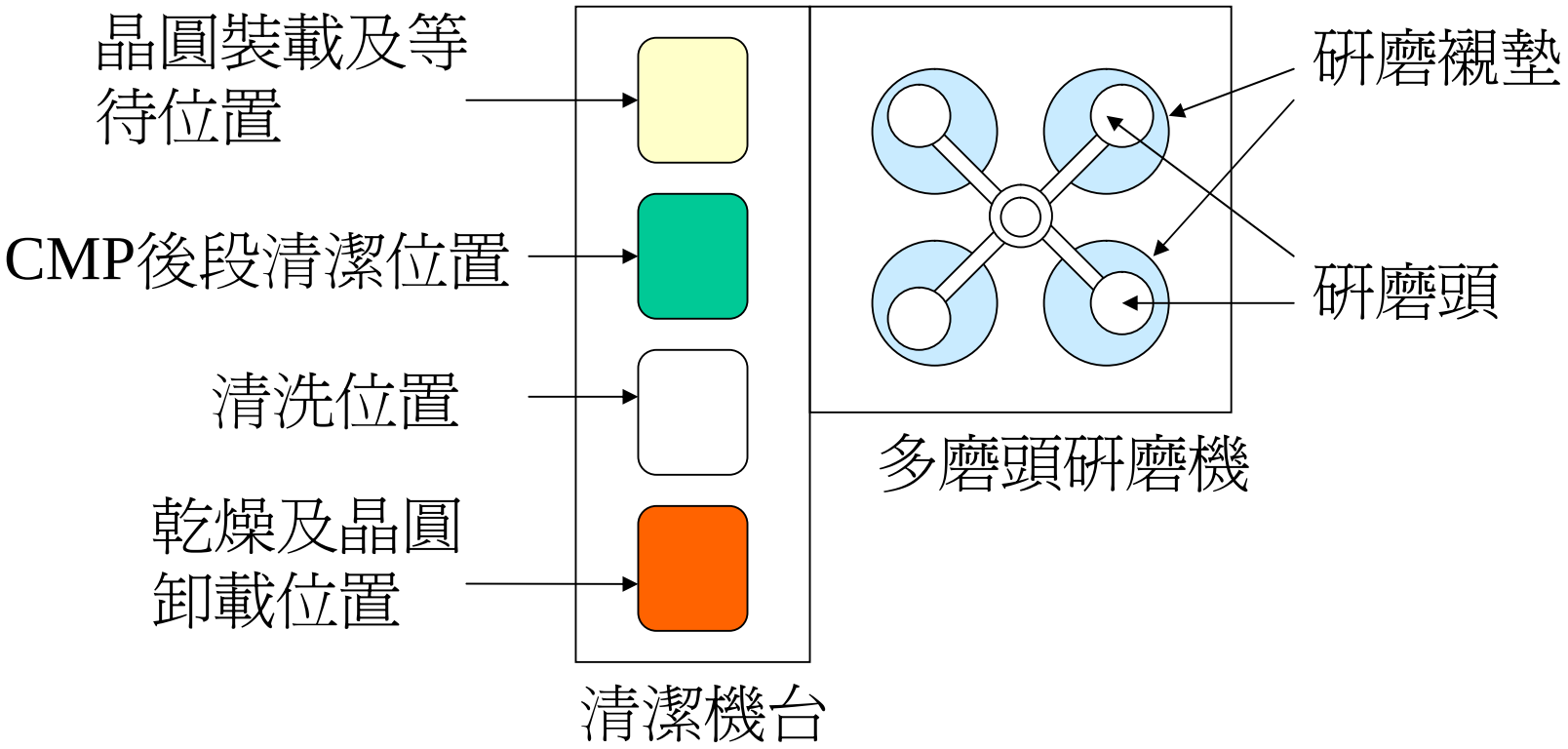
具備介電質化學氣相沈積及回蝕刻反應室的群集工具示意圖



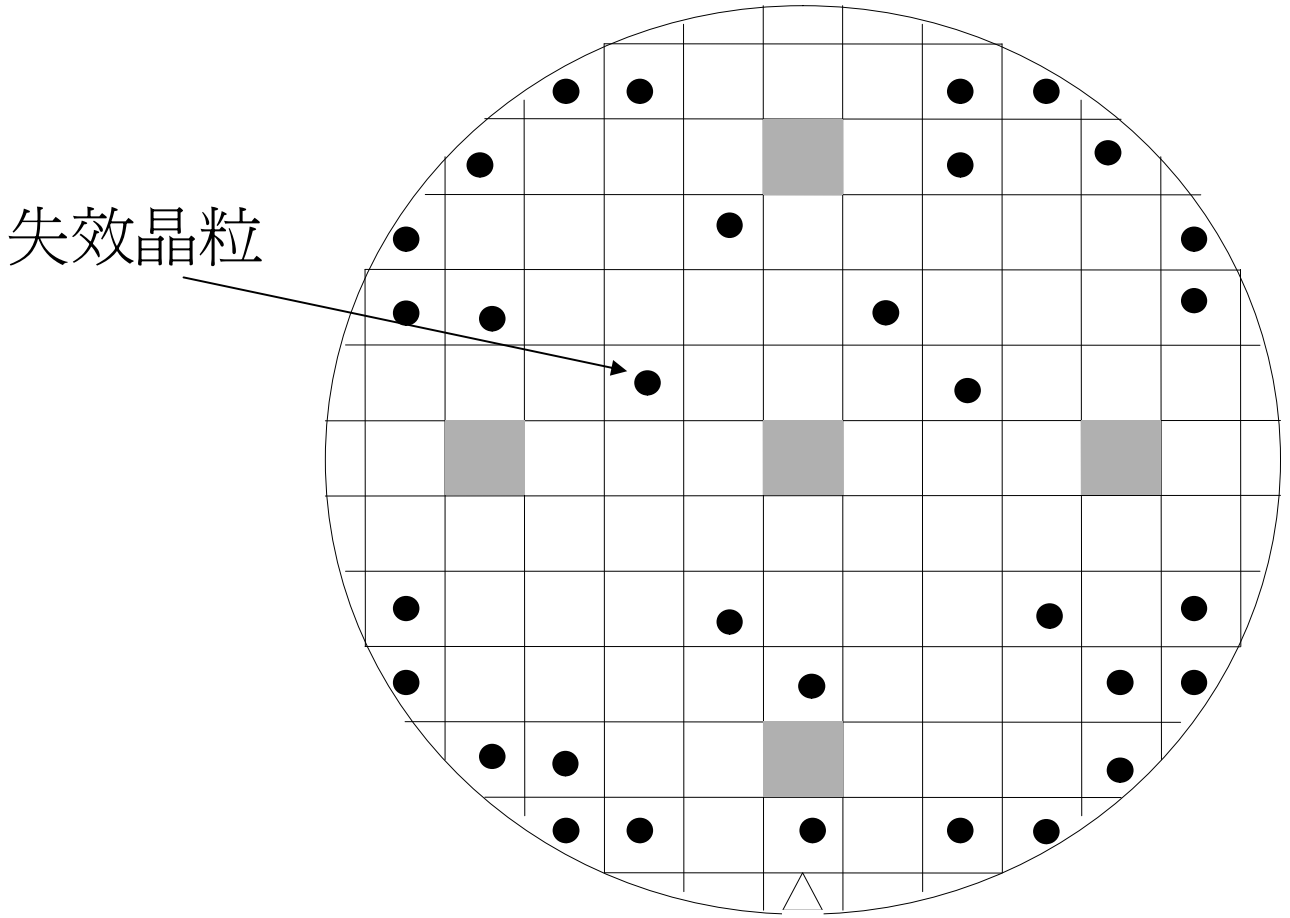
物理氣相沈積反應室的群集工具示意圖

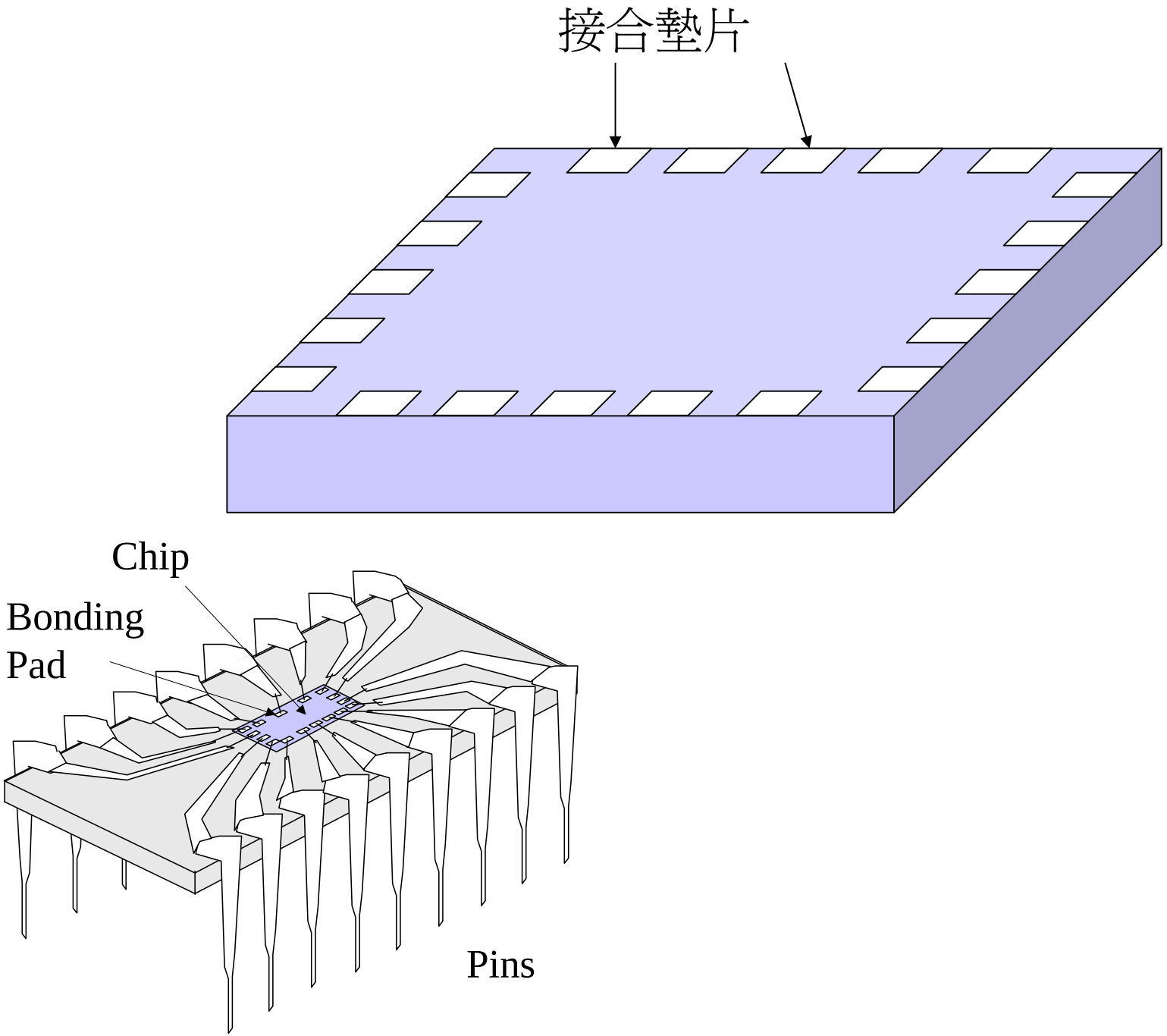


乾進、乾出多研磨頭 CMP系統

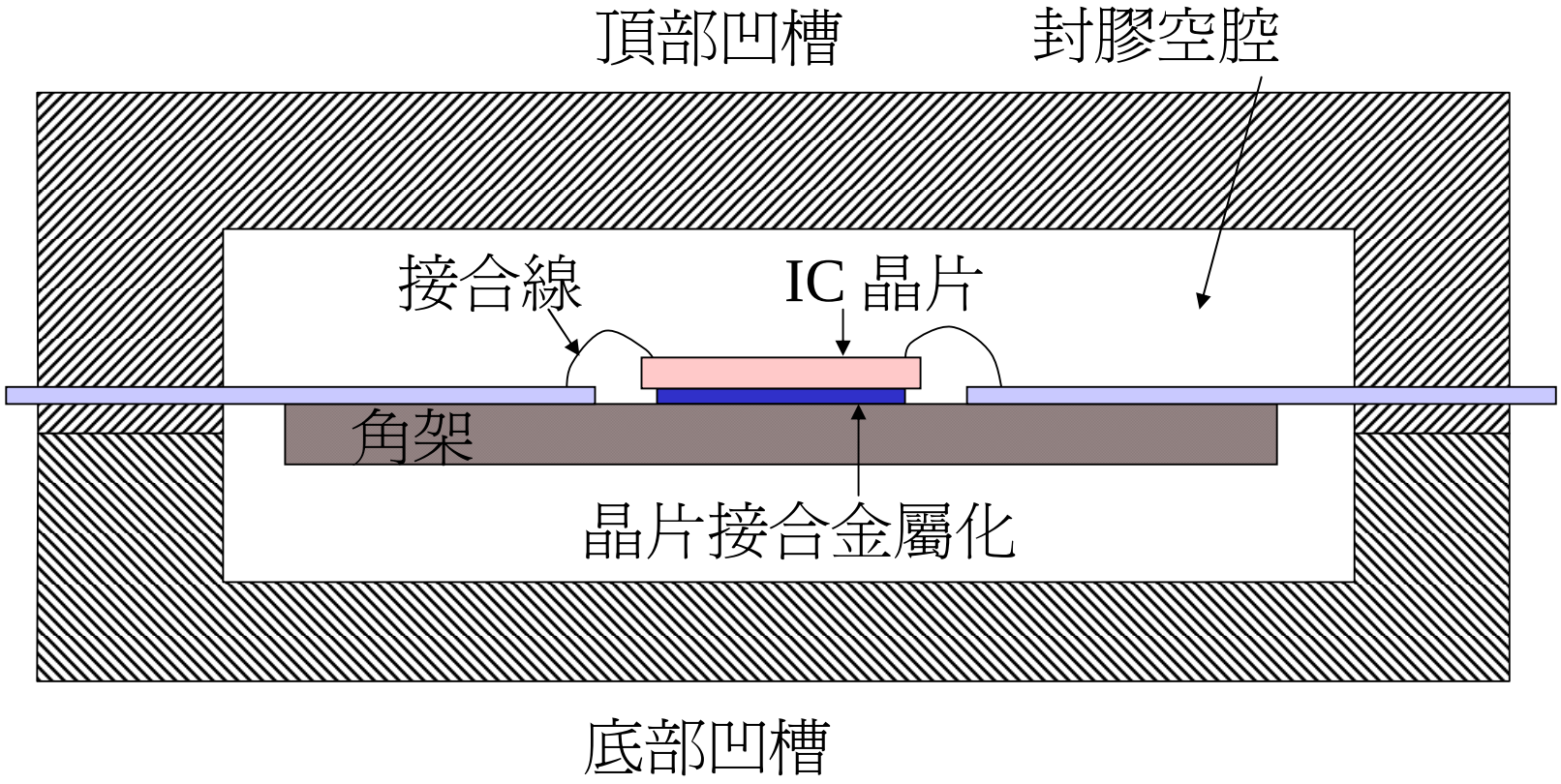


測試結果

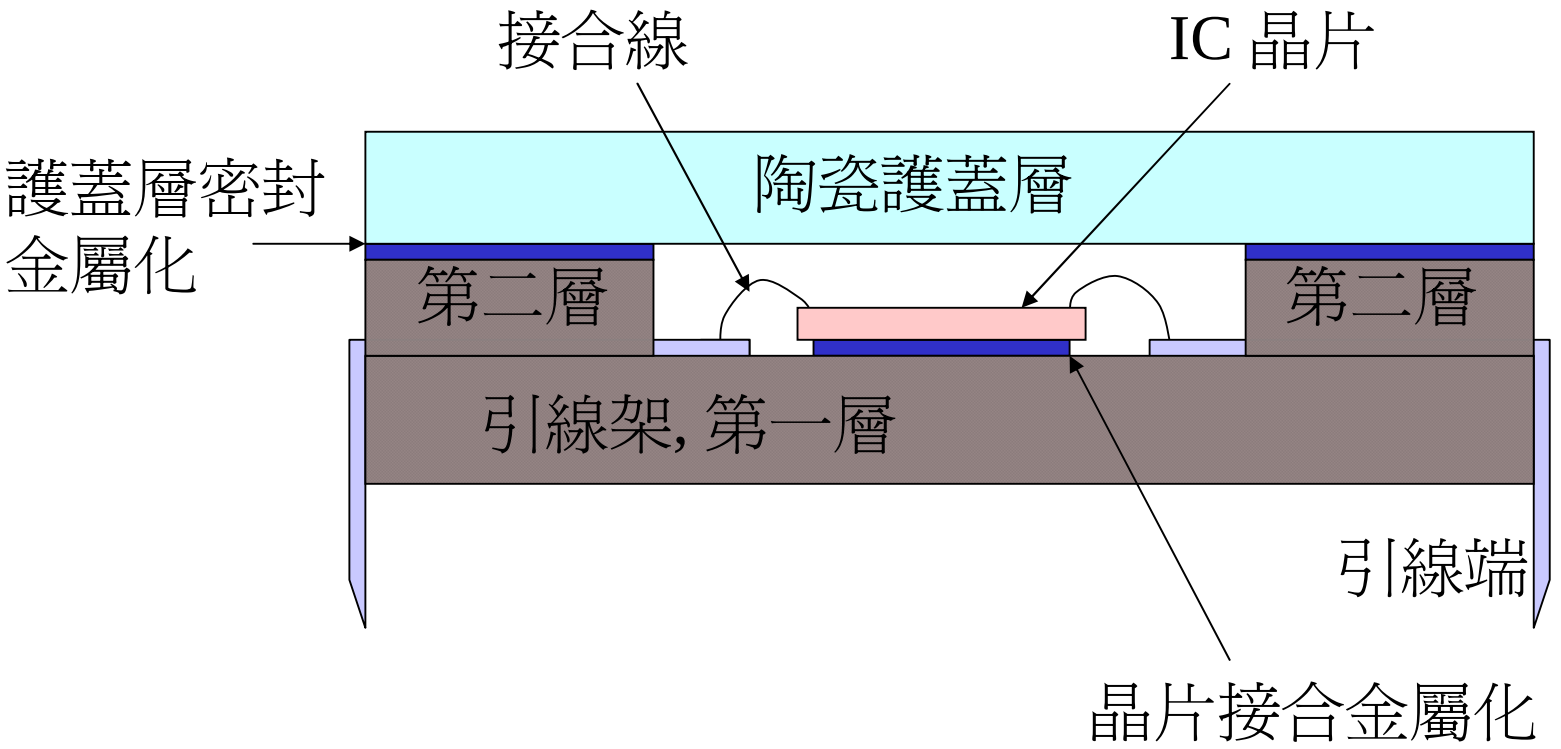



接合墊片
Chip
Bonding
Pad
Pins

塑膠封裝（如記憶體）



陶瓷封裝 (如CPU)



能帶

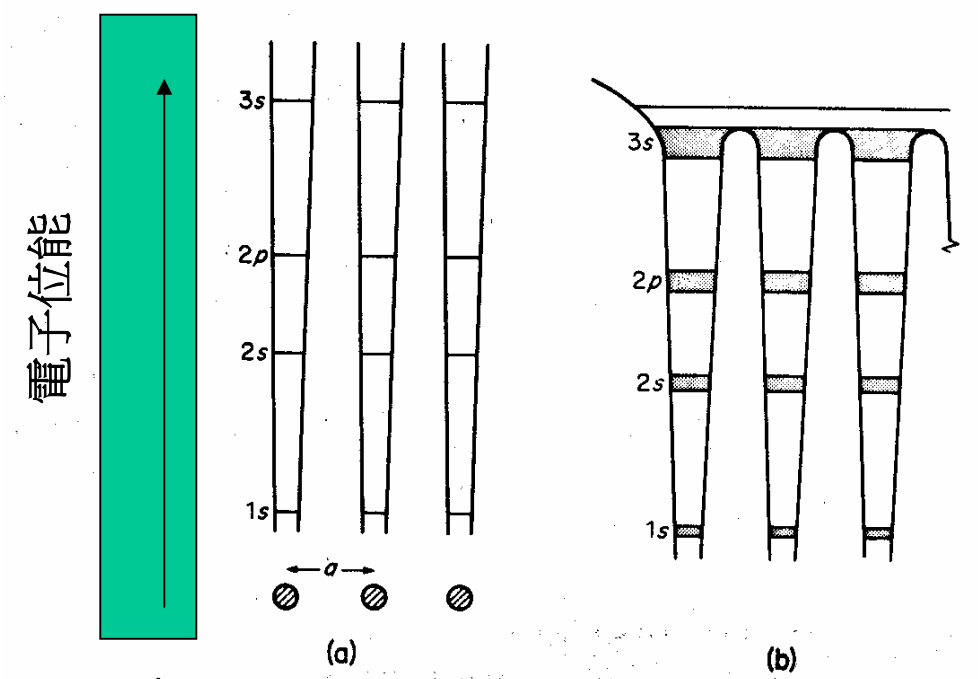
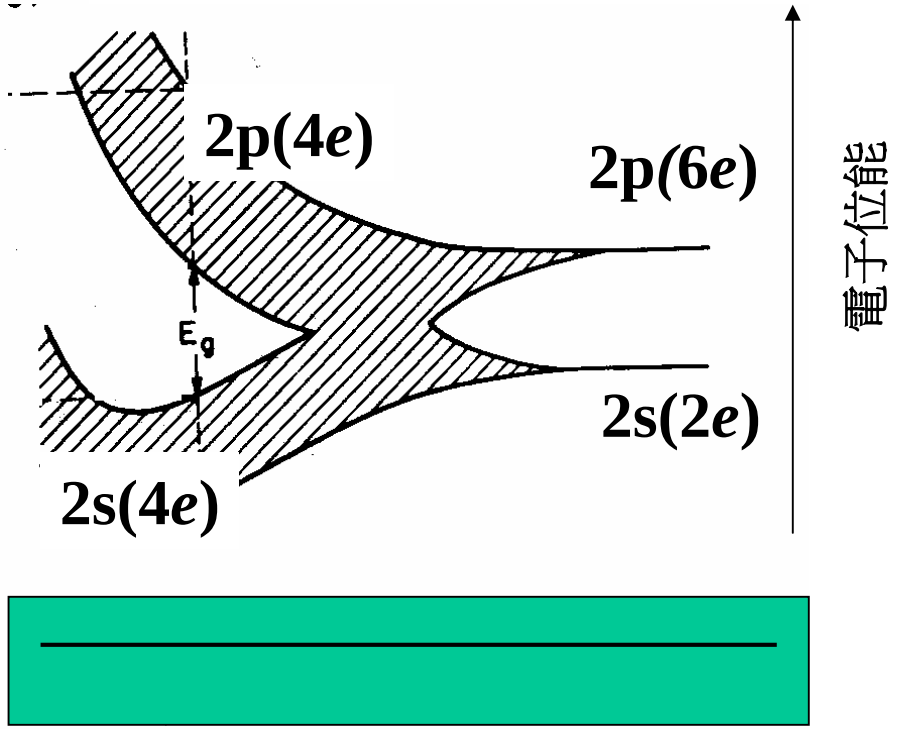
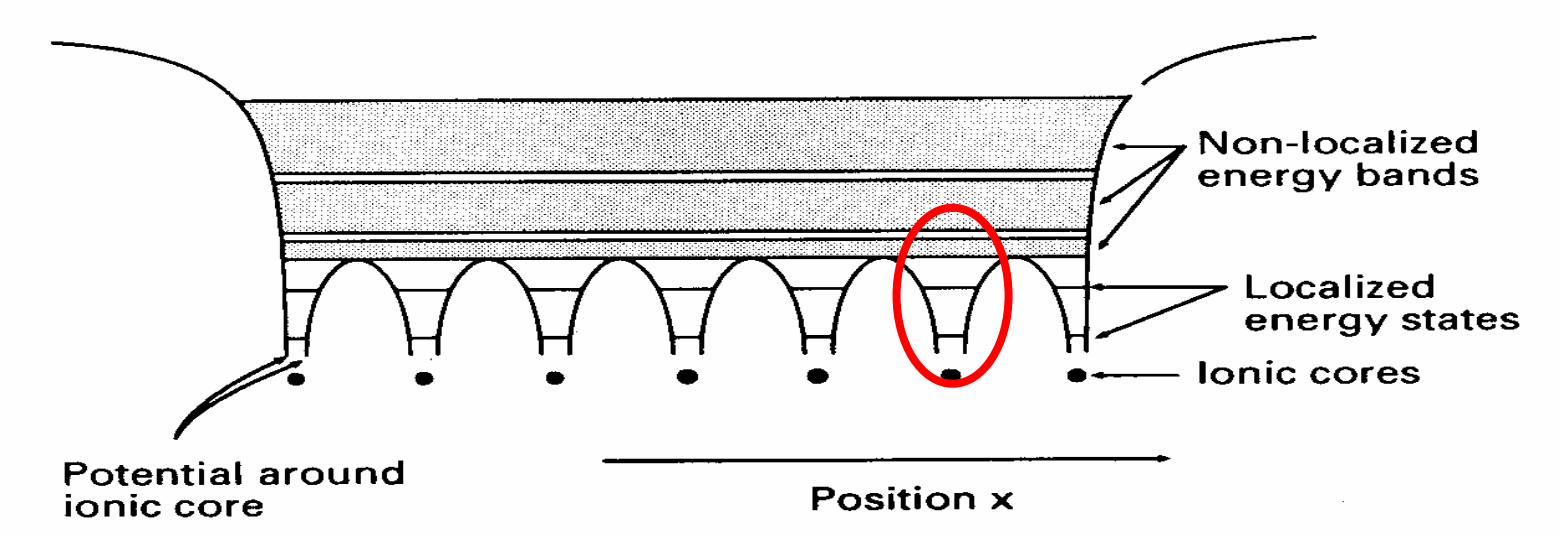
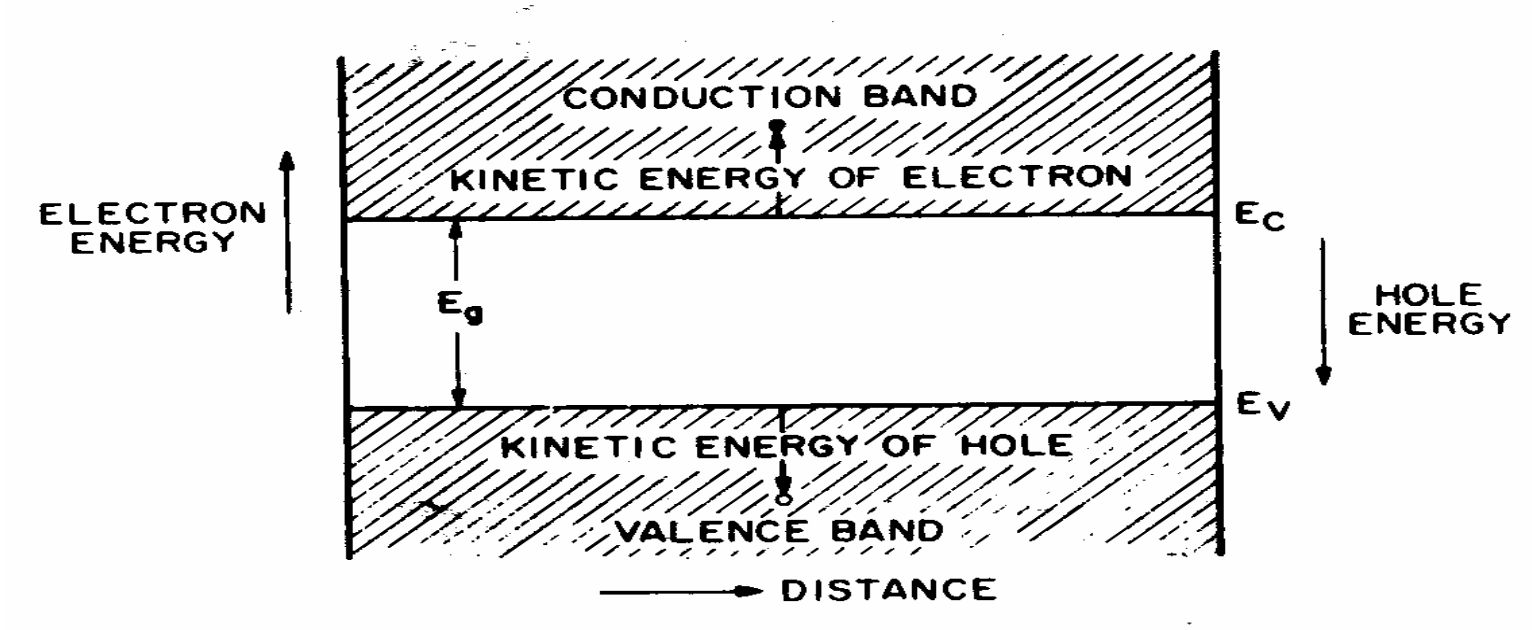


FIG. 18.29 Energy levels in sodium: (a) isolated atoms; (b) section of crystal. The sharp levels in the atom have become bands in the crystal.

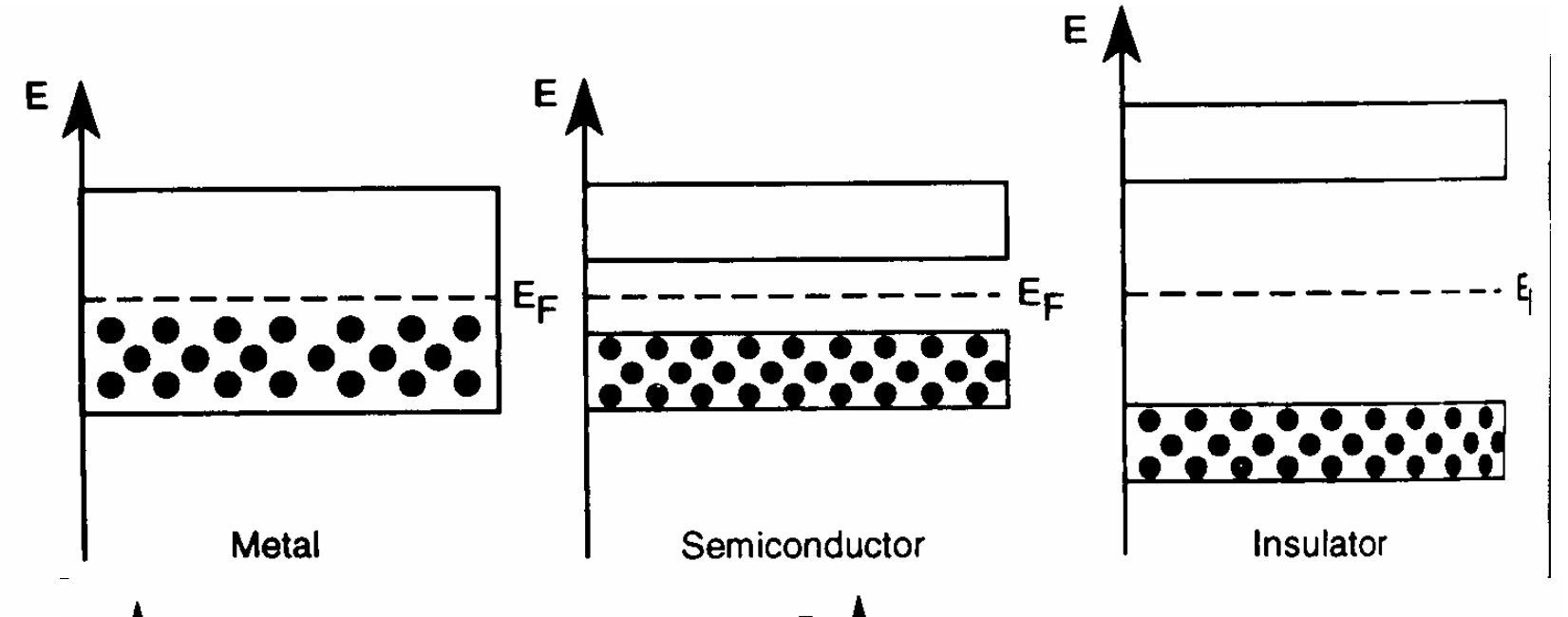


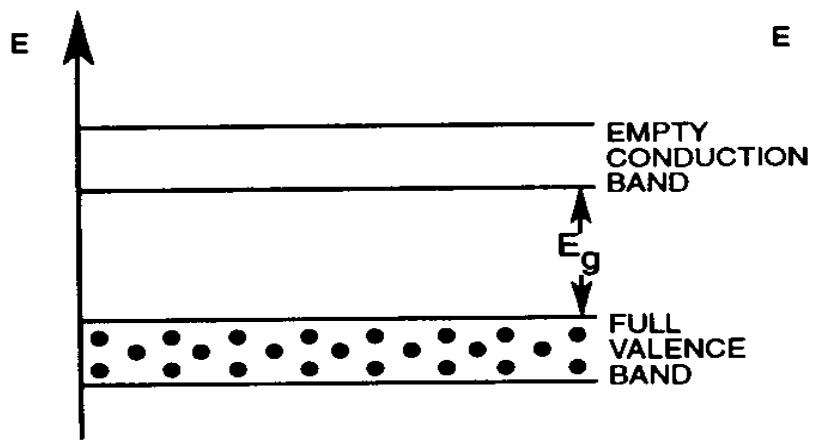
能帶


Non-localized
energy bands
Localized
energy states
Ionic cores
Potential around
ionic core
Position x

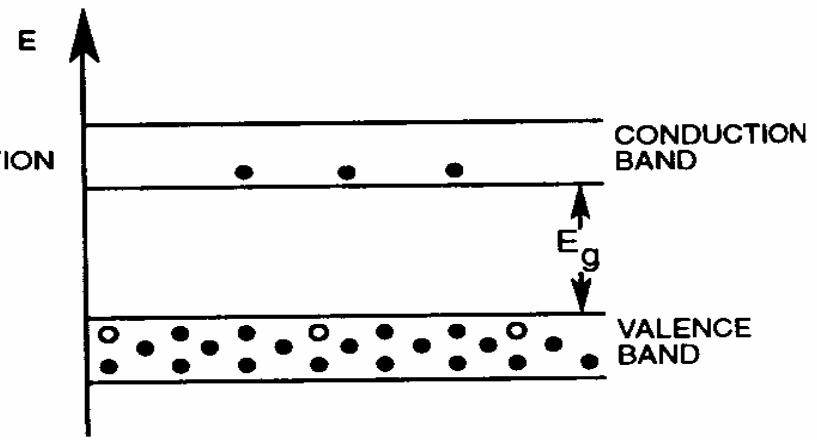

CONDUCTION BAND
KINETIC ENERGY OF ELECTRON
ELECTRON
ENERGY
E_C
E_g
HOLE
ENERGY
E_V
KINETIC ENERGY OF HOLE
VALENCE BAND
DISTANCE

能帶



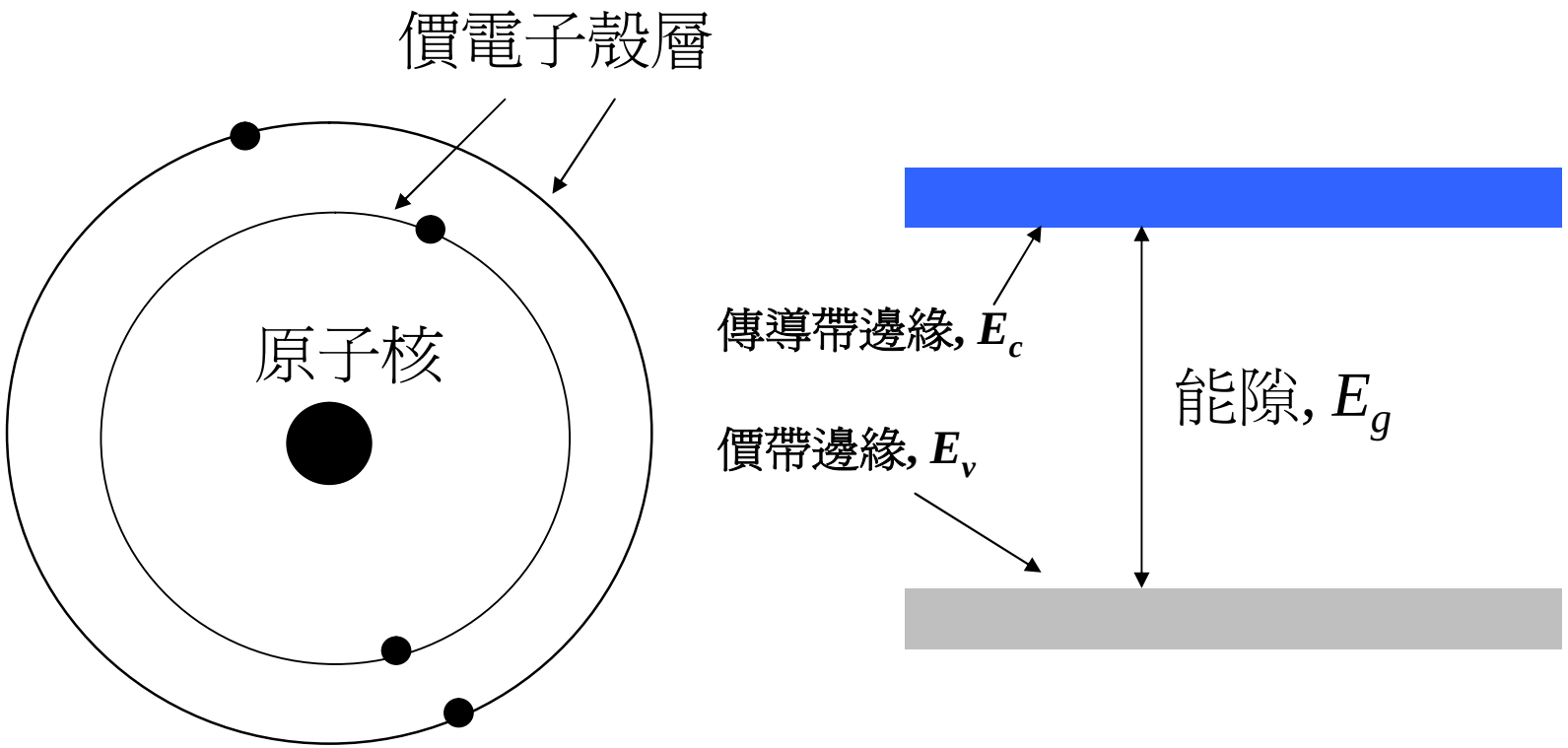


Intrinsic semiconductor
at 0 K

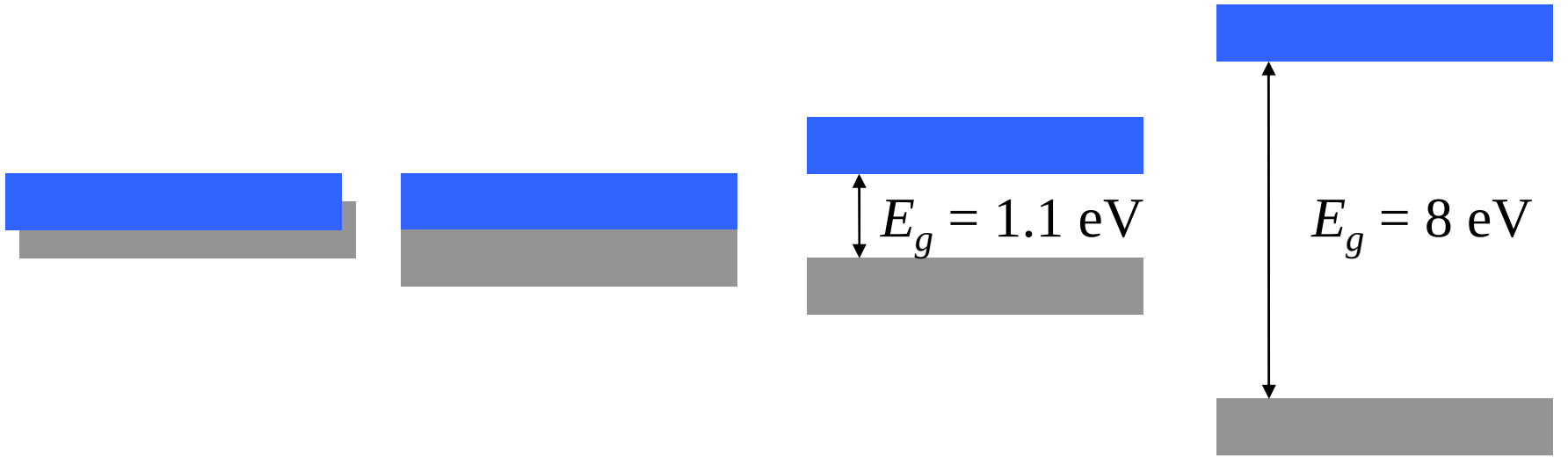


Intrinsic semiconductor
at 300 K.
Some electrons have

原子的軌域及能帶結構



能隙及電阻率



鋁2.7
μΩ•cm

鈉4.7
μΩ•cm

矽~ 10^{10}
μΩ•cm

二氧化矽
> 10^{20} μΩ•cm

導體

半導體

絕緣體