



MICROSCOPES WITH INTELLIGENCE



Harvest
Scientific
Corporation

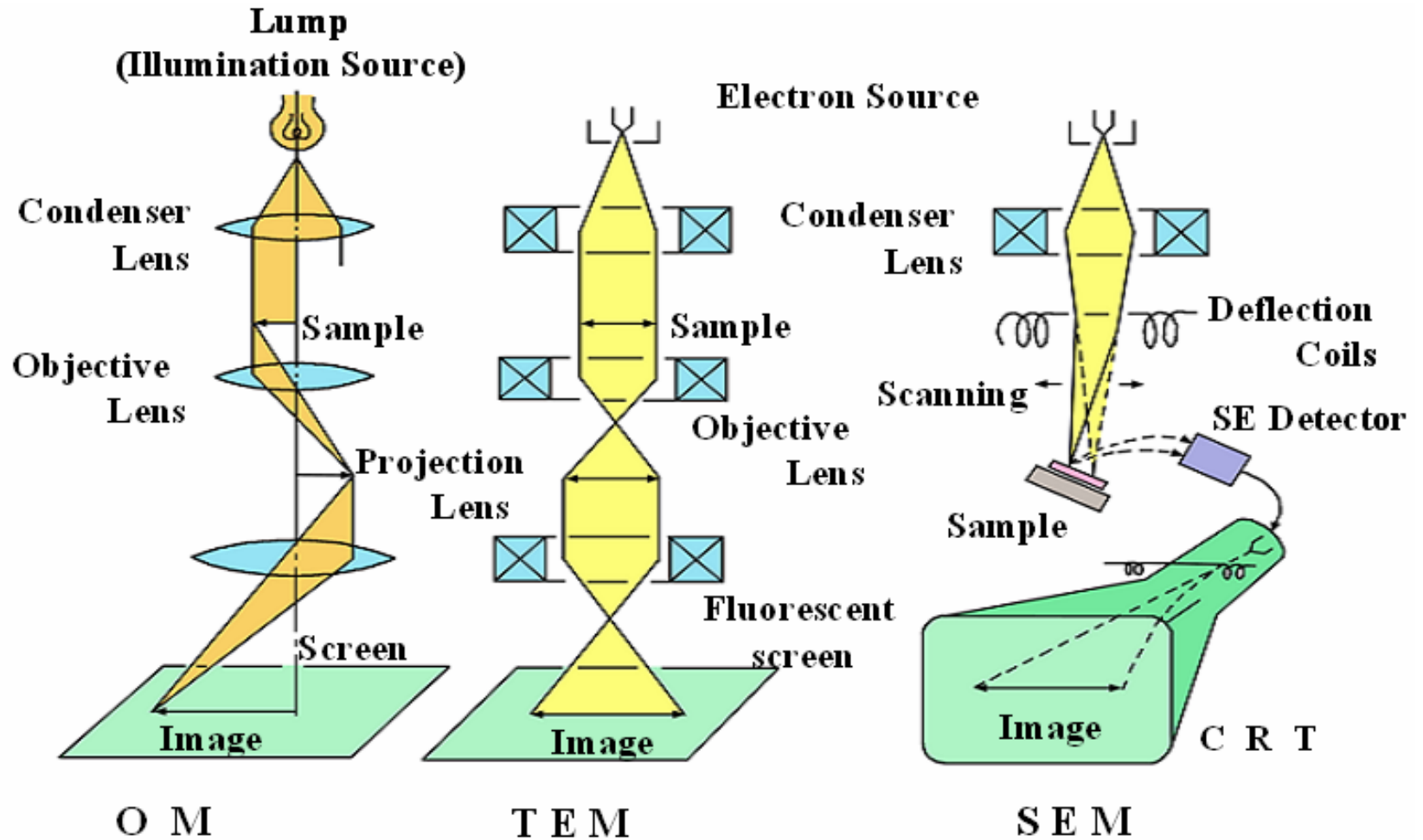
www.tescan.com



电子显微镜原理

Theory of Electron Microscope

OM , TEM & SEM成像原理



Difference among OM, TEM and SEM

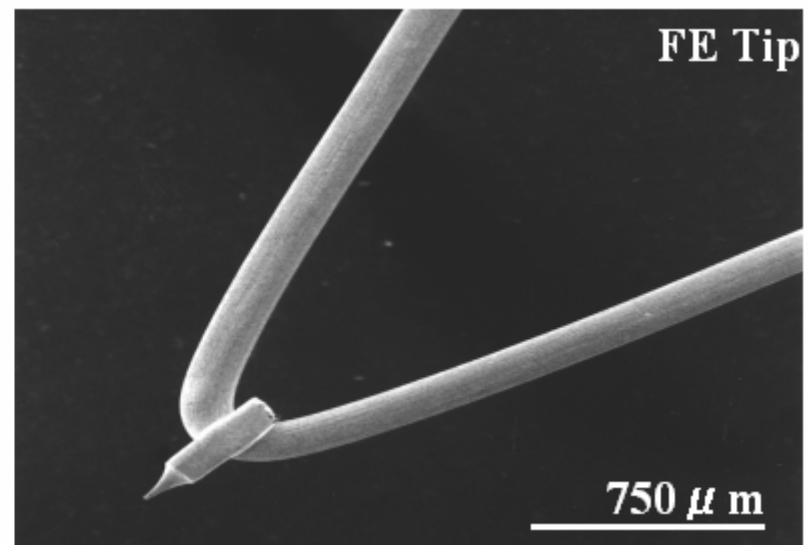
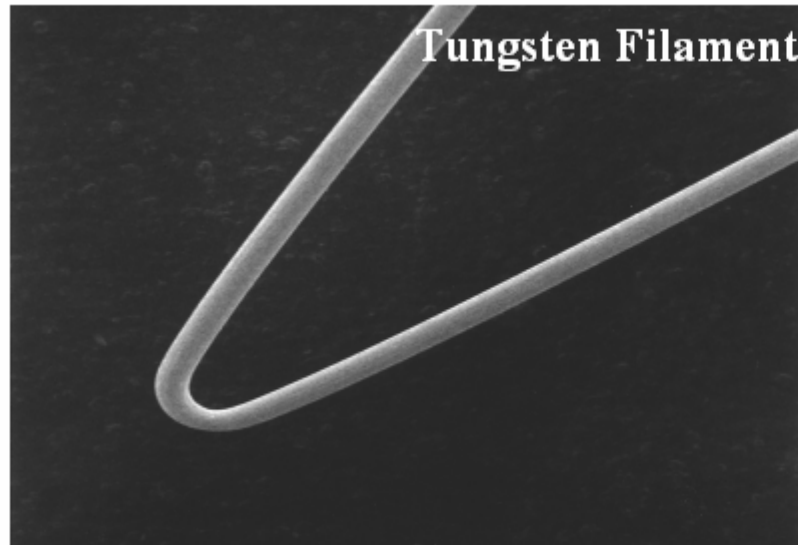
OM , TEM & SEM比较表

Characteristic		Type	O M	T E M	S E M
Hardware	Voltage		—	High Voltage 25~300kV	High Voltage 0.5~30kV
	Illumination Source		Light	Electron	Electron
	Observation		In Air	In Vacuum	In Vacuum
	Lens		Glass	Pole Piece	Pole Piece
Software Performance	Resolution		5 ~ 0.1 μ m	0.5 ~ 0.1 nm	7 ~ 0.6 nm
	Focus Depth (X500)		Shallow (2~3 μ m)	Deep (500 μ m)	Deep (0.1~1mm)
	x-rays Analysis		Not possible	Possible	Possible
	Color		Color	Black and White	Black and White
	Magnification		~ × 1K	~ × 1000K	~ × 800K
	Field of View		Large	Small	Large
	Specimen Preparation		Easy	Complicated	Easy
	Specimen Size		Large	Small	Large
	Metal coating		Not necessary	Not necessary	Necessary
	Image		Transmitted Image or Surface Image	Transmitted Image	Surface Image

各種燈絲比較表

	熱游離式	熱游離式	Cold Field Emission	Schottky Field Emission
陰極材料	W	LaB ₆	W(310)	ZrO/W(100)
工作溫度(K)	2800	1900	300	1800
陰極半徑(nm)	60000	10000	≤100	≤1000
電流密度(A/cm ²)	3	30	17000	5300
輝度 Brightness (A/cm ² .sr.kV)	10 ⁴	10 ⁵	2×10 ⁷	10 ⁷
能量散佈(eV)	0.59	0.4	0.26	0.31
真空度(torr)	≤10 ⁻⁵	≤10 ⁻⁶	≤10 ⁻¹⁰	≤10 ⁻⁸
燈絲壽命(hr)	200	1000	2000	2000

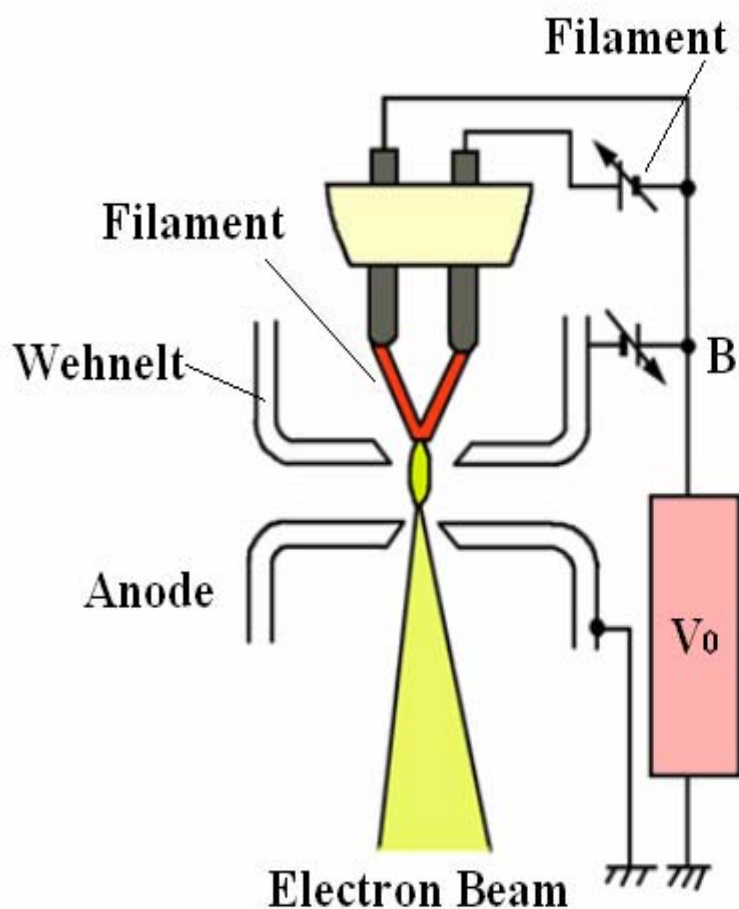
钨丝/场效灯丝比較表



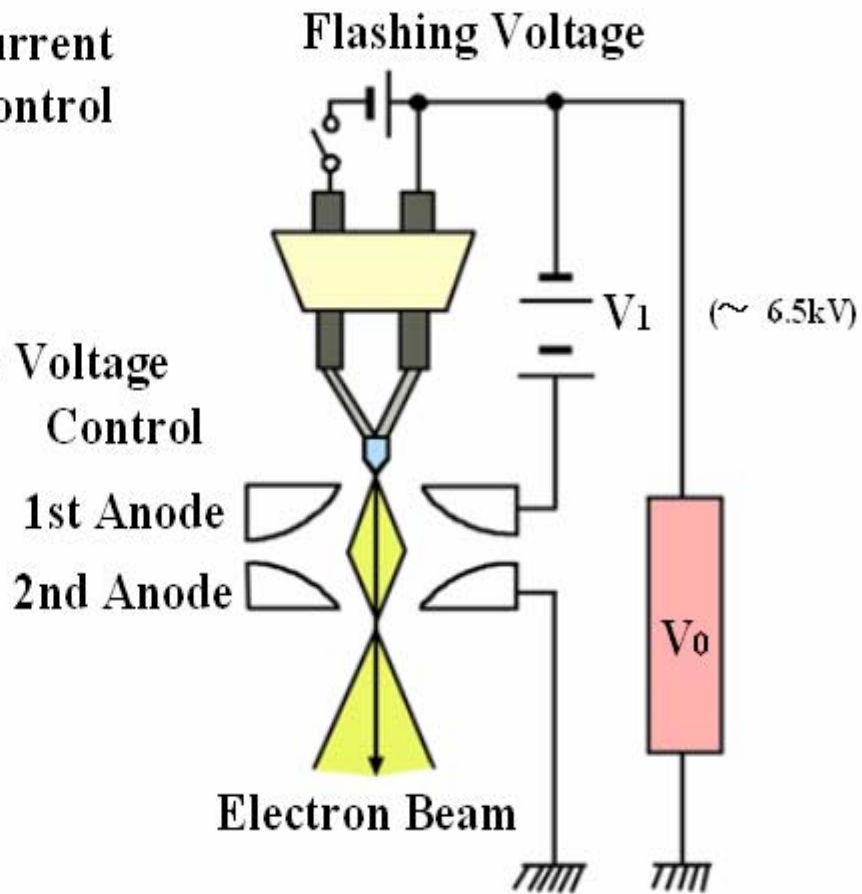
Electron Source	Tungsten Filament	Field Emission
Type of Emission	Thermonic	Cold FE
Operating Vacuum (Pa)	10^{-5}	$\sim 10^{-8}$
Brightness ($A/cm^2 \cdot str$)	5×10^5	10^8
Source Size (μ m)	30	0.01
Energy Spread (eV)	2.0	0.2
Life Time (h)	50	2000

Comparison of electron sources

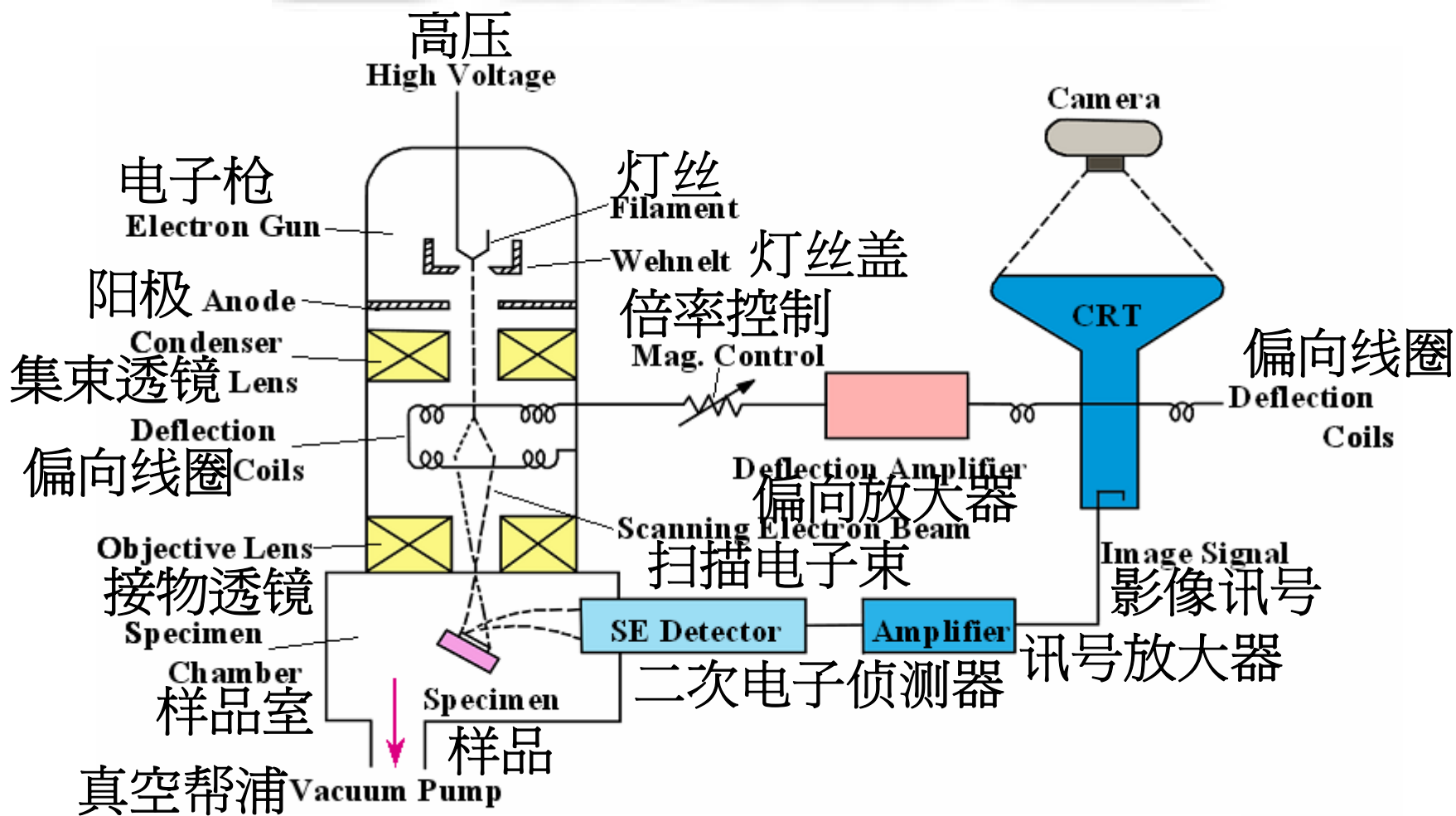
冷/热场效电子显微镜灯丝构造



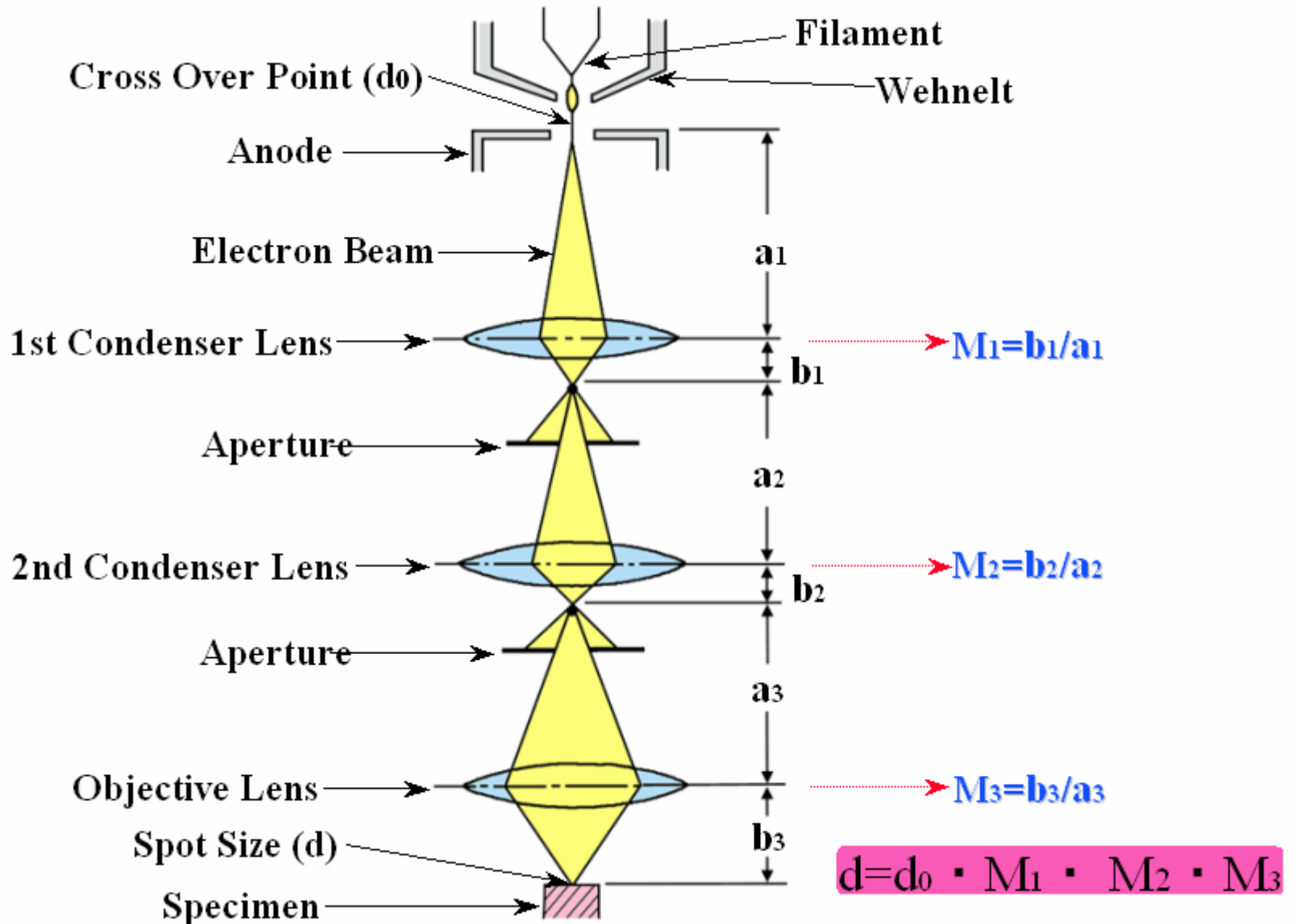
Thermionic Emission



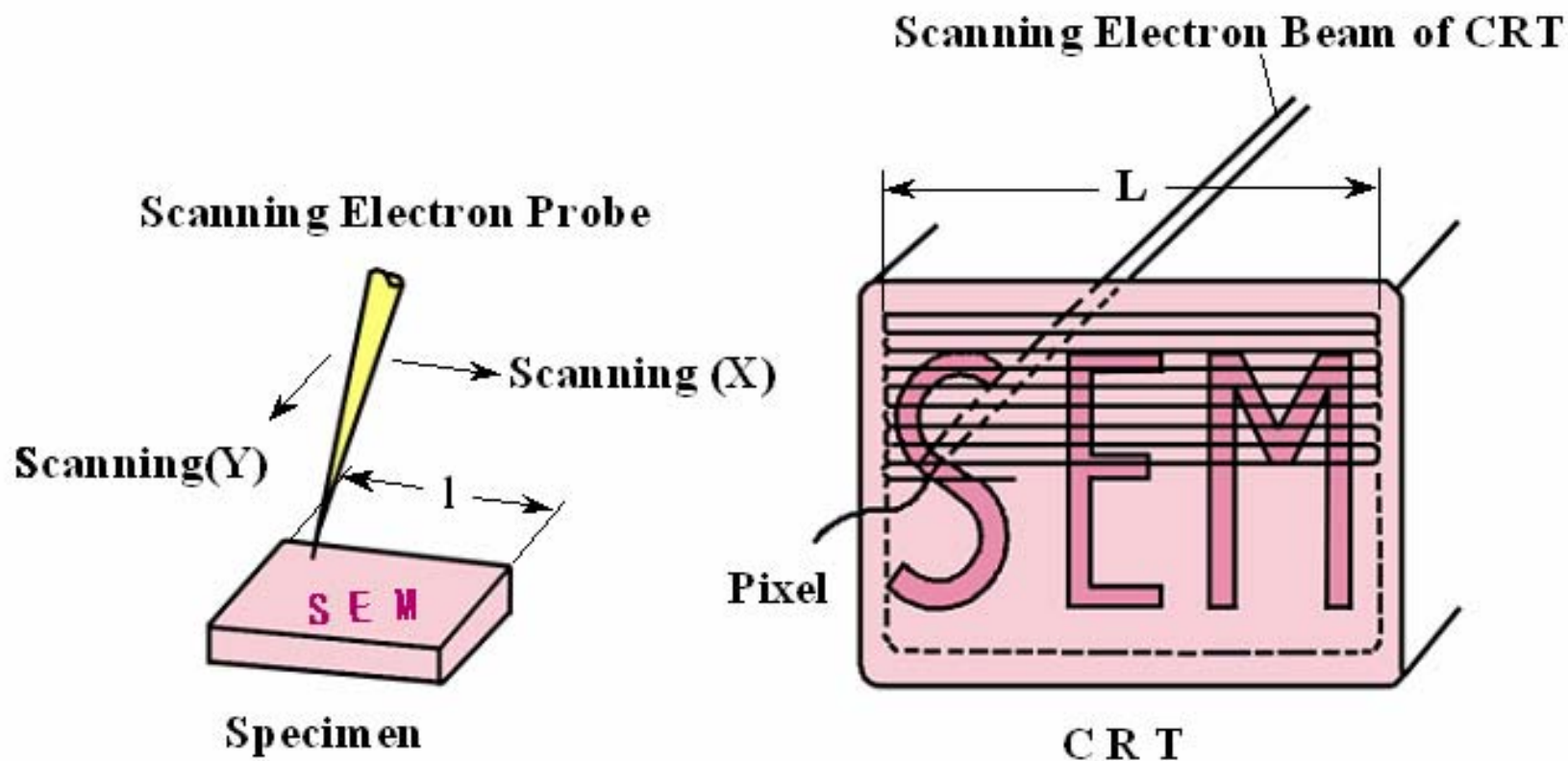
Cold Field Emission



掃描式电子显微镜的透镜系統

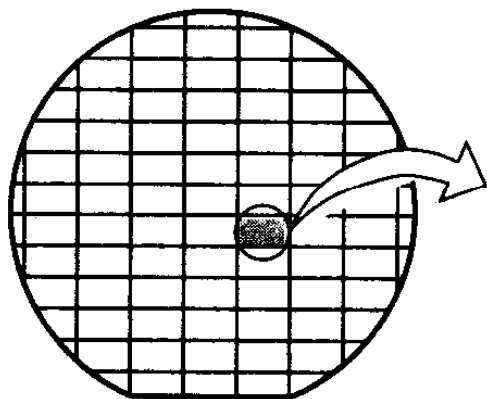


掃描式電子顯微鏡放大原理

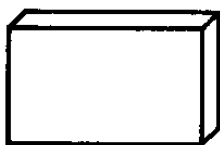


$$\text{Magnification : } (M) = L / l$$

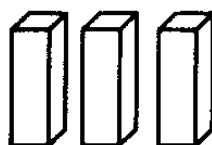
TEM 樣品製作過程



Wafer



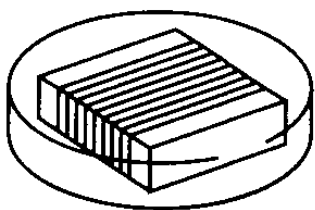
Device



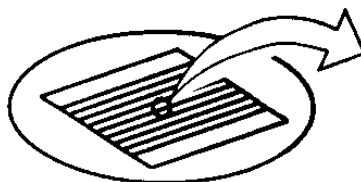
Cut device
into sections



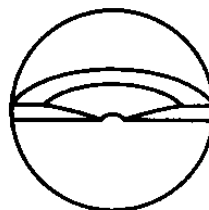
Thin sections
to 100 mils



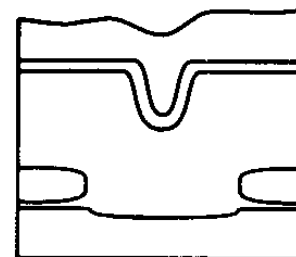
Stack sections,
seal in epoxy



Polish, ion
mill to 100 mils

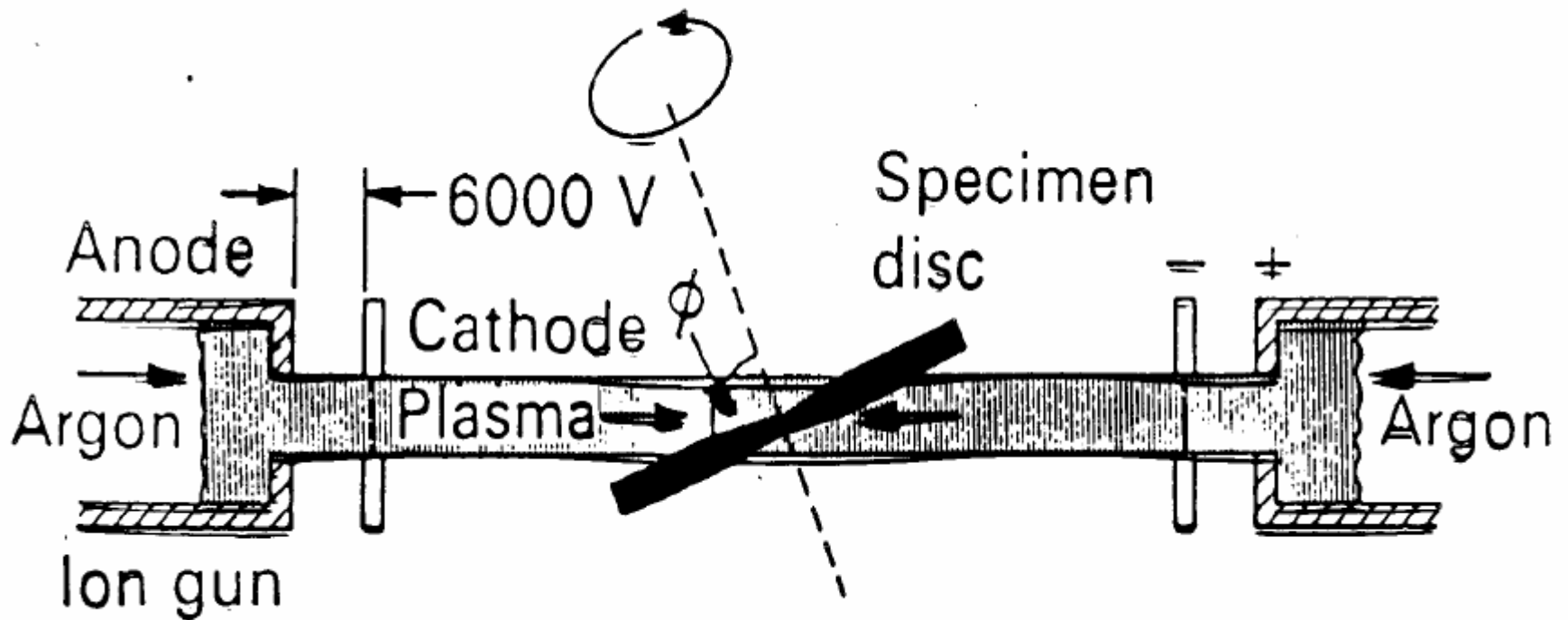


Ion milled
hole

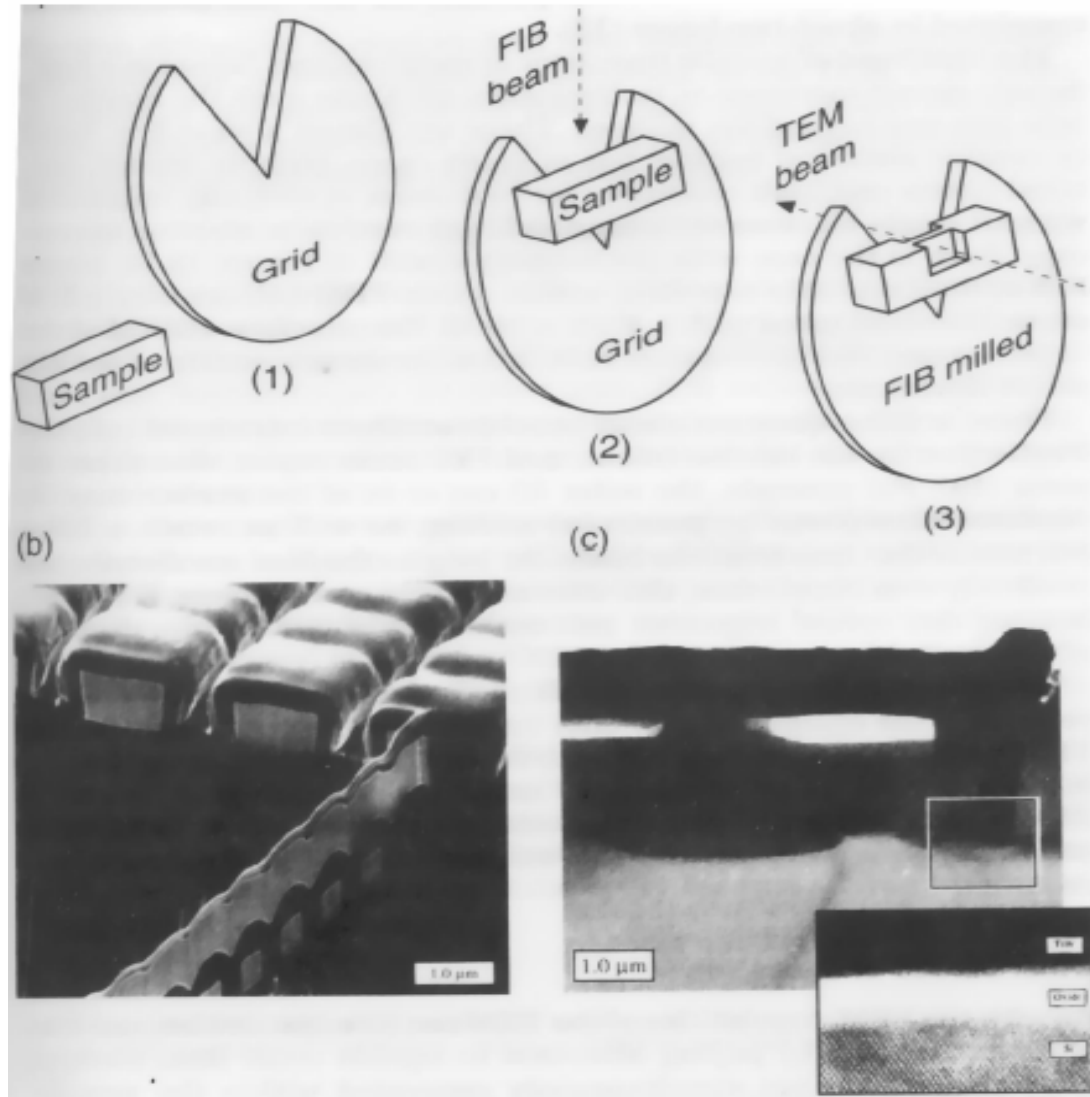


TEM
image

Ion Milling原理構造



Focus Ion Beam 樣品處理



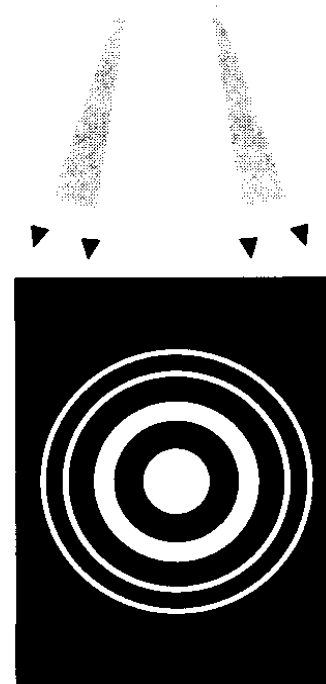
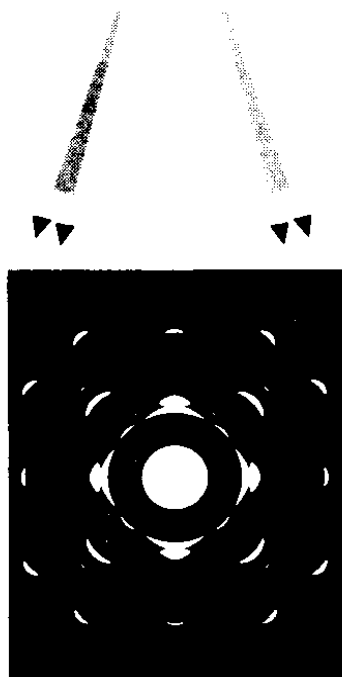
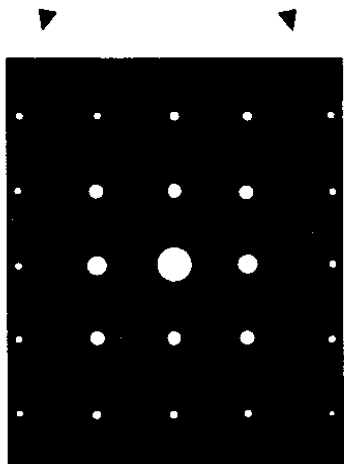
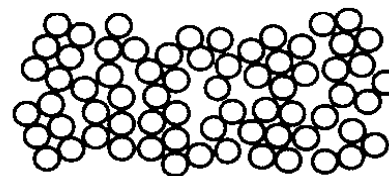
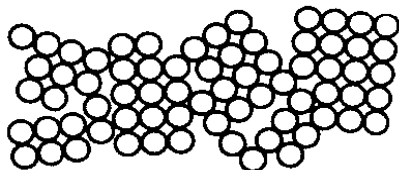
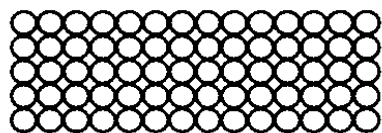
TEM 的電子繞射圖

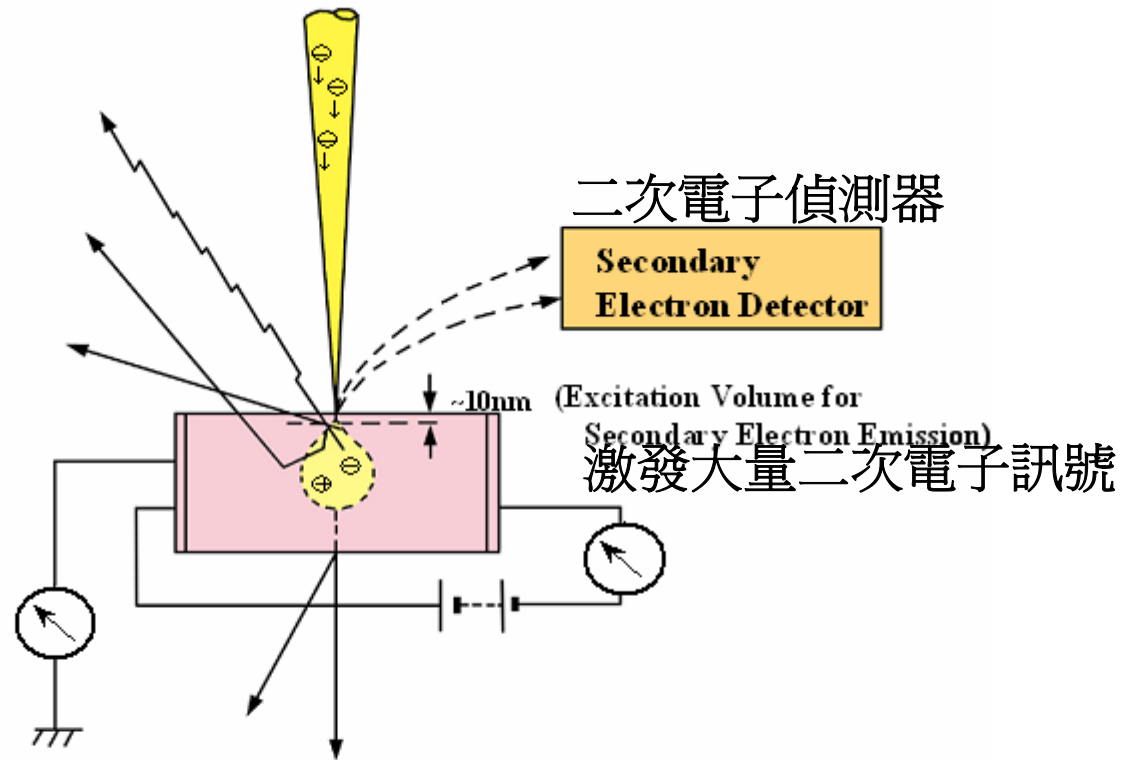
(a) Single crystal

(b) Aligned grains

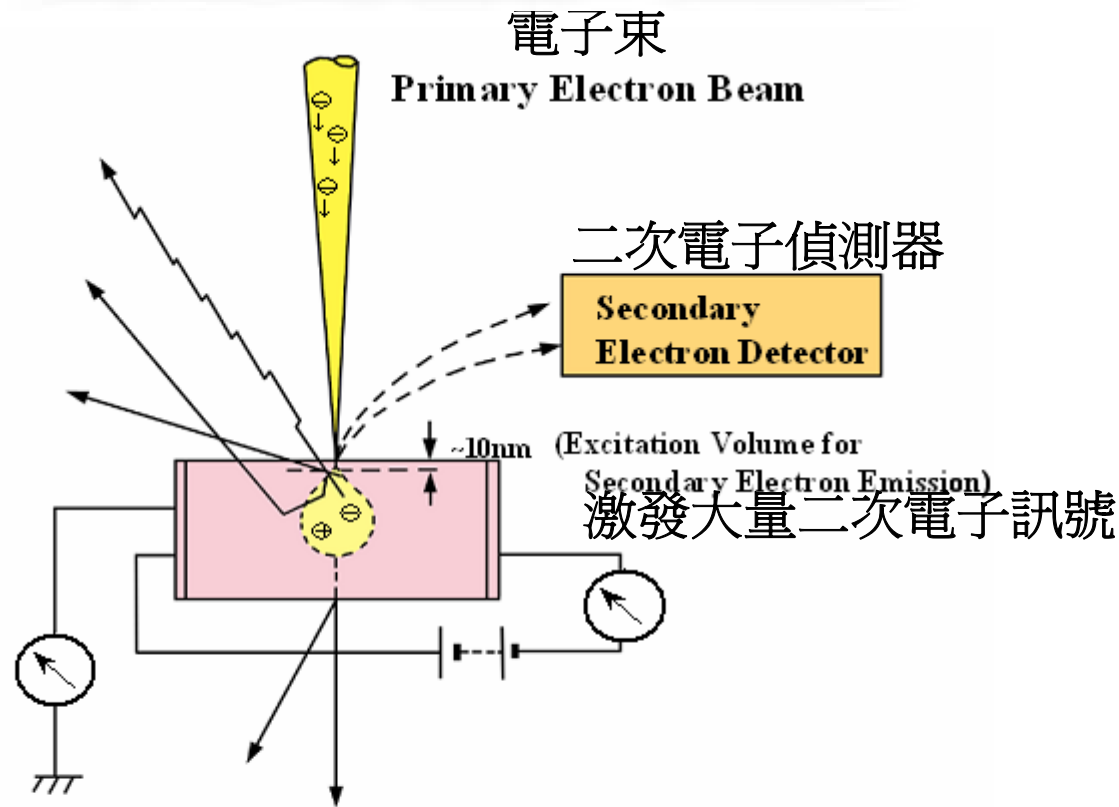
(c) Random grains

Au

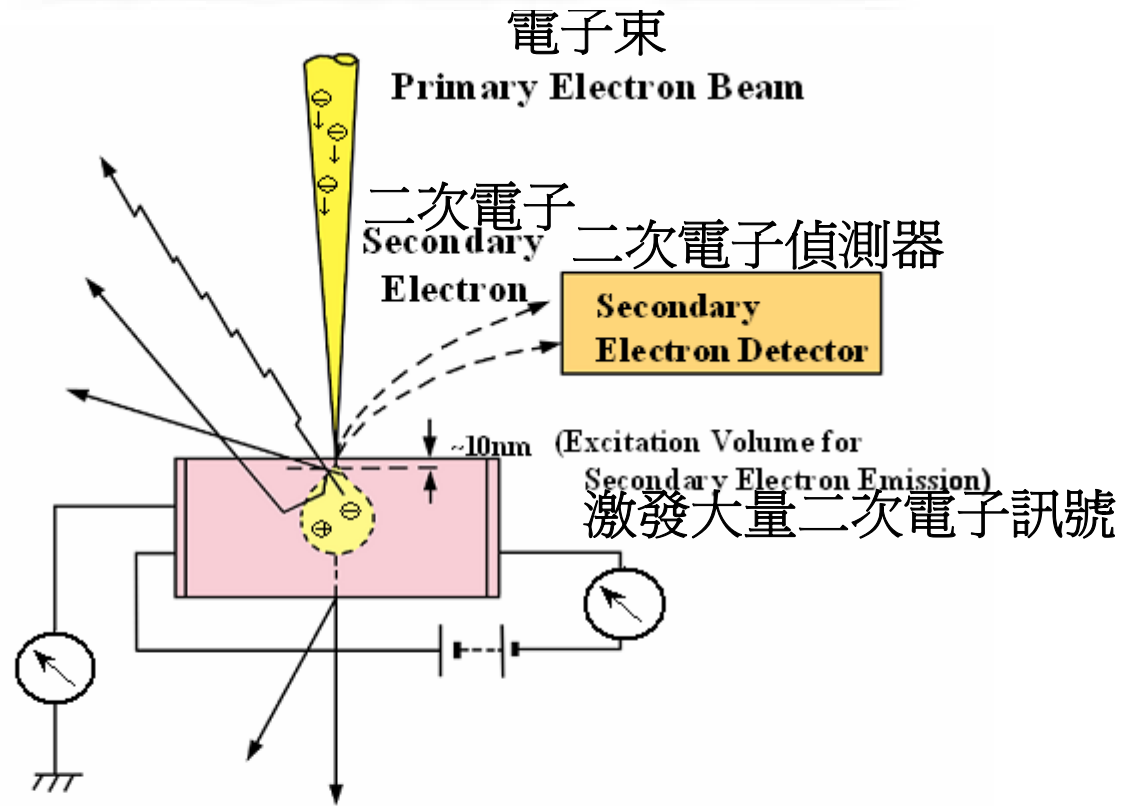




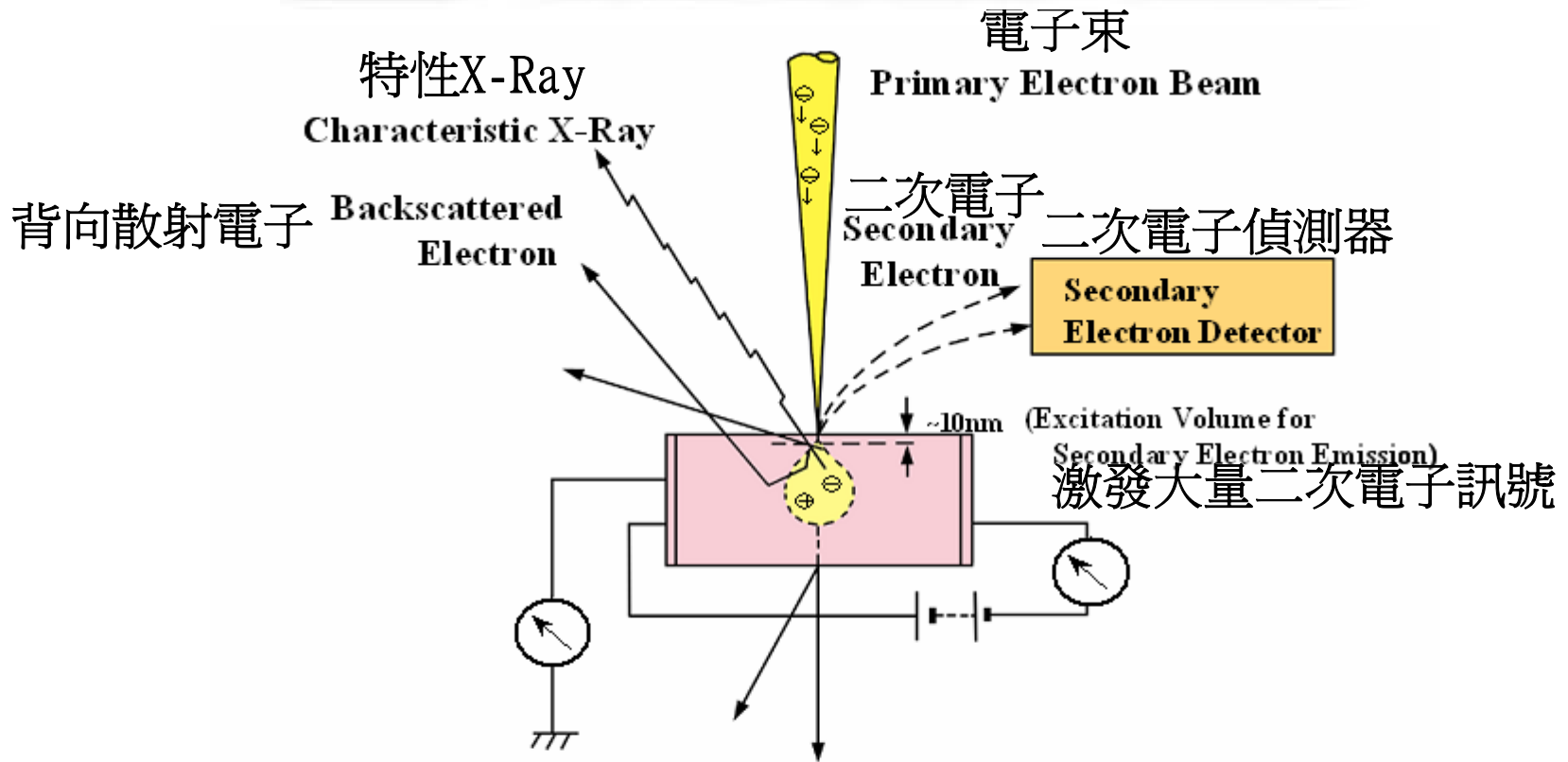
**The primary electron beam-specimen
interaction in the SEM**



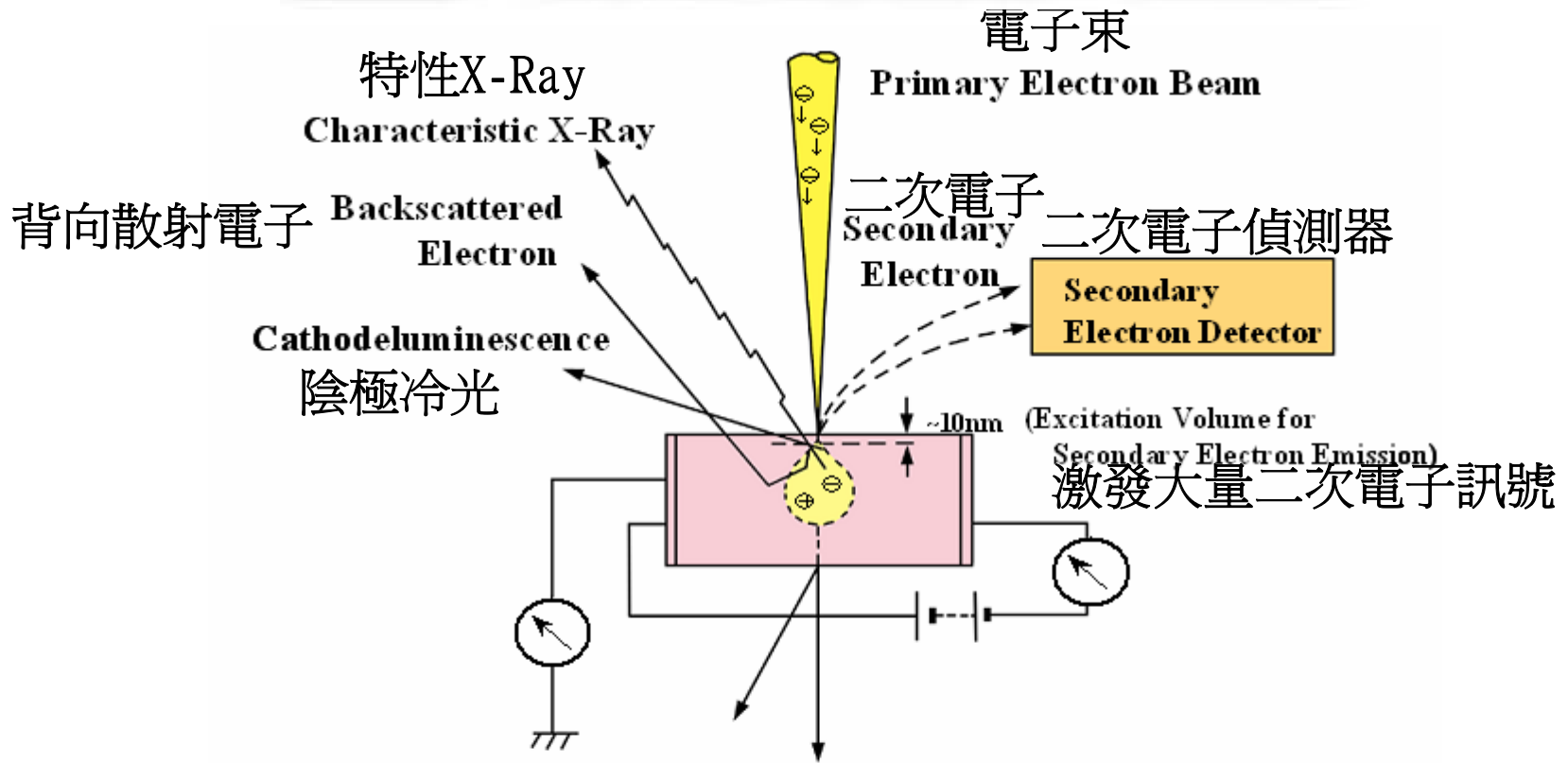
**The primary electron beam-specimen
interaction in the SEM**



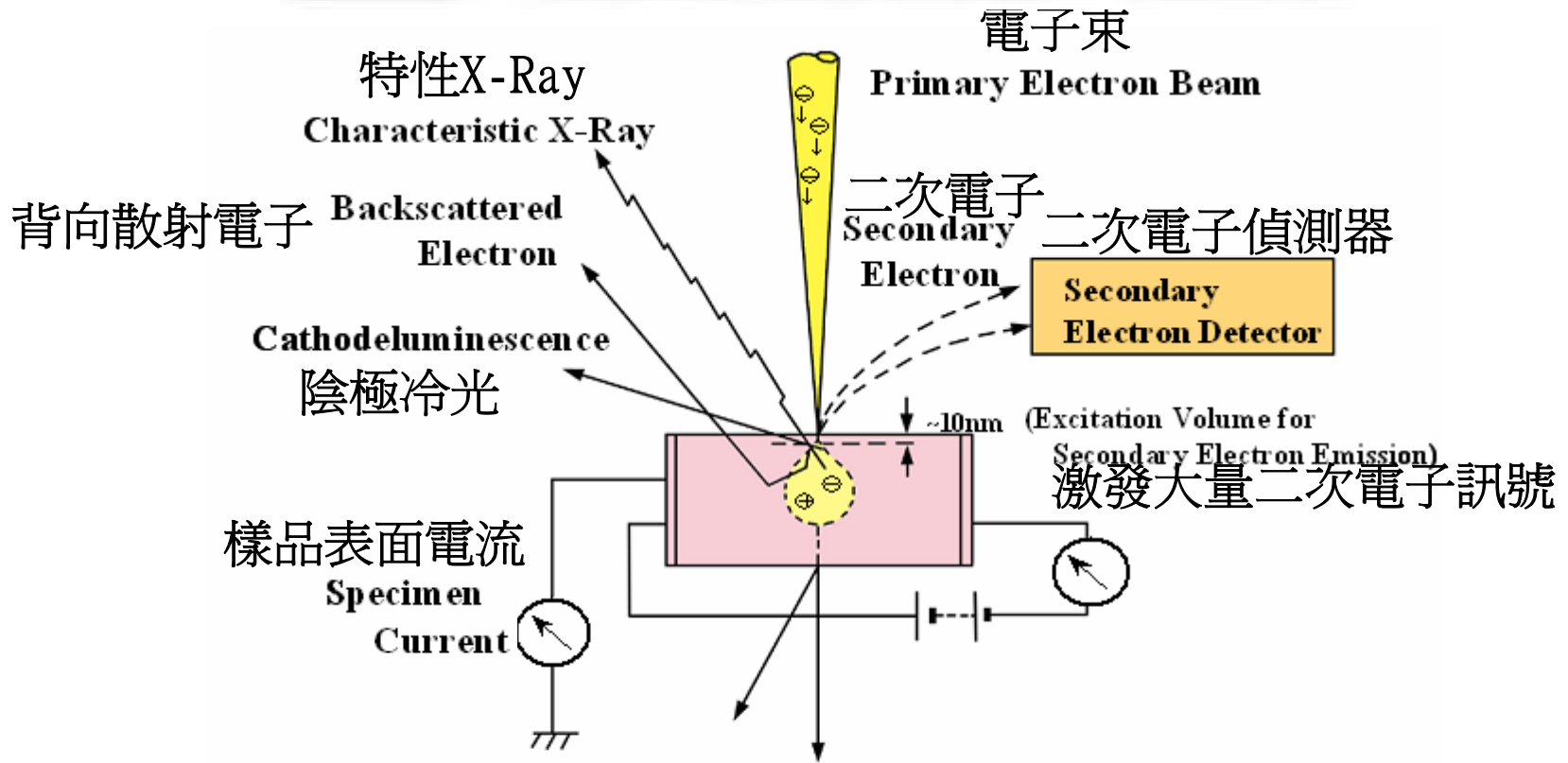
**The primary electron beam-specimen
interaction in the SEM**



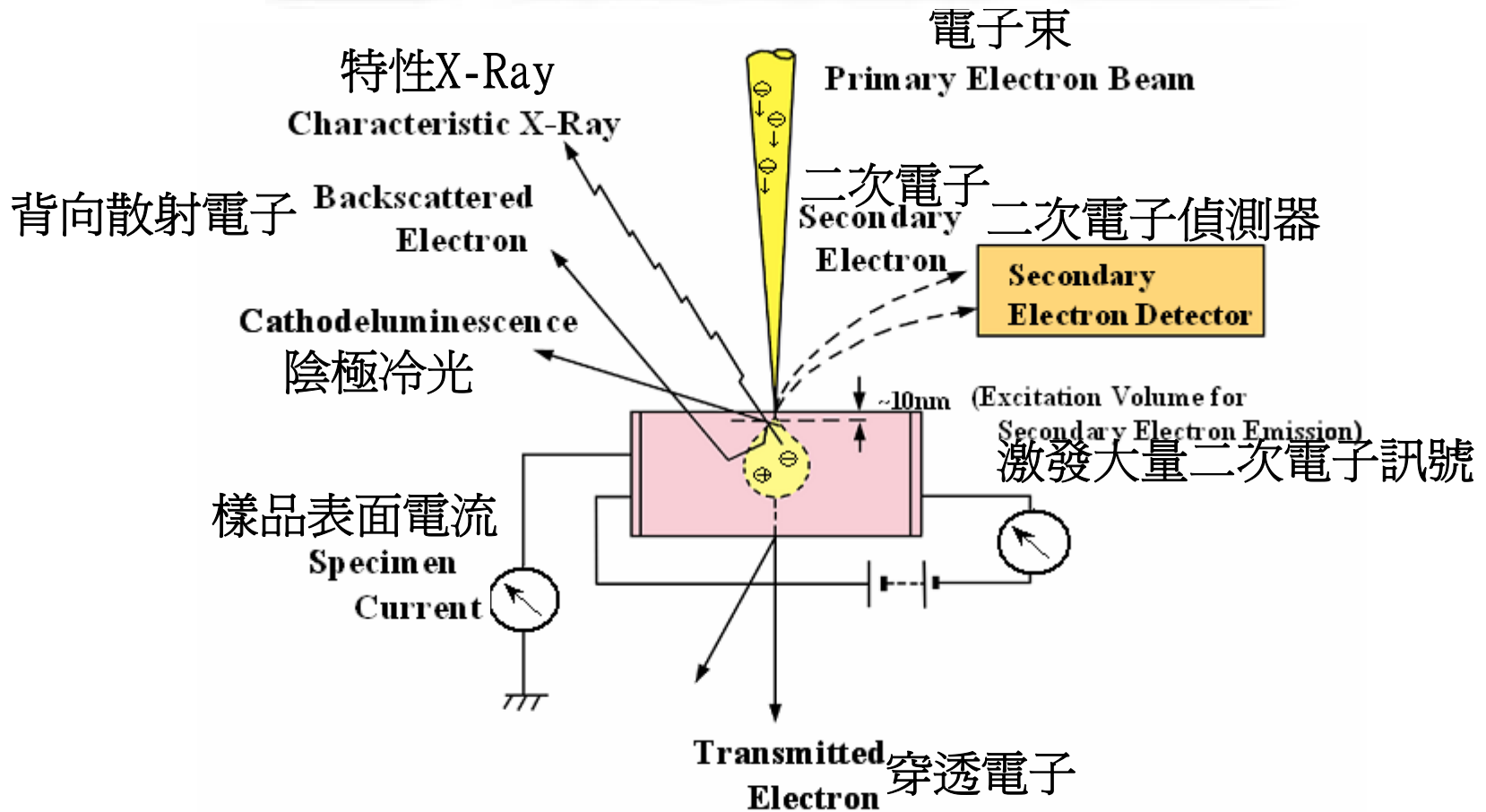
**The primary electron beam-specimen
interaction in the SEM**



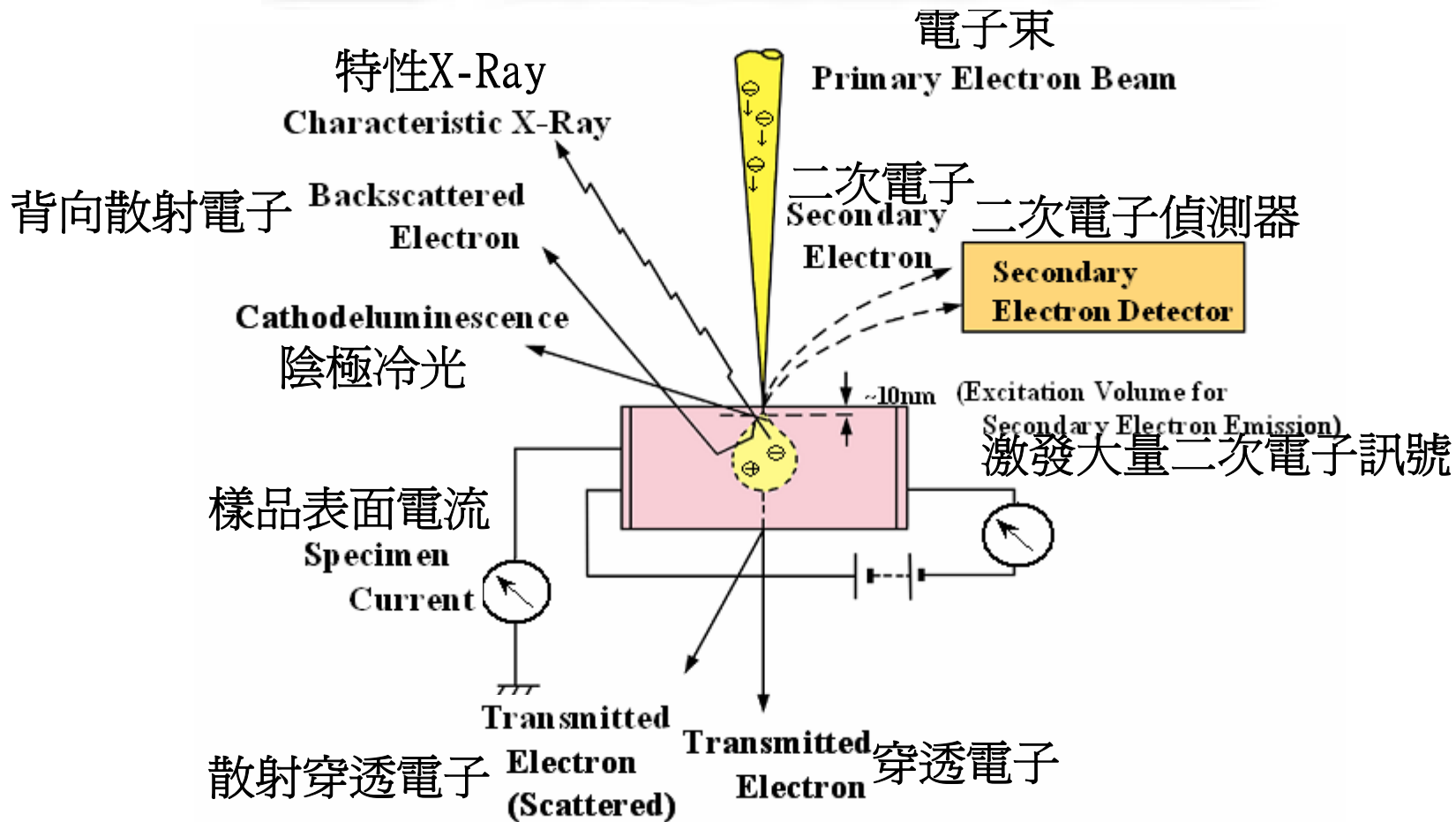
The primary electron beam-specimen interaction in the SEM



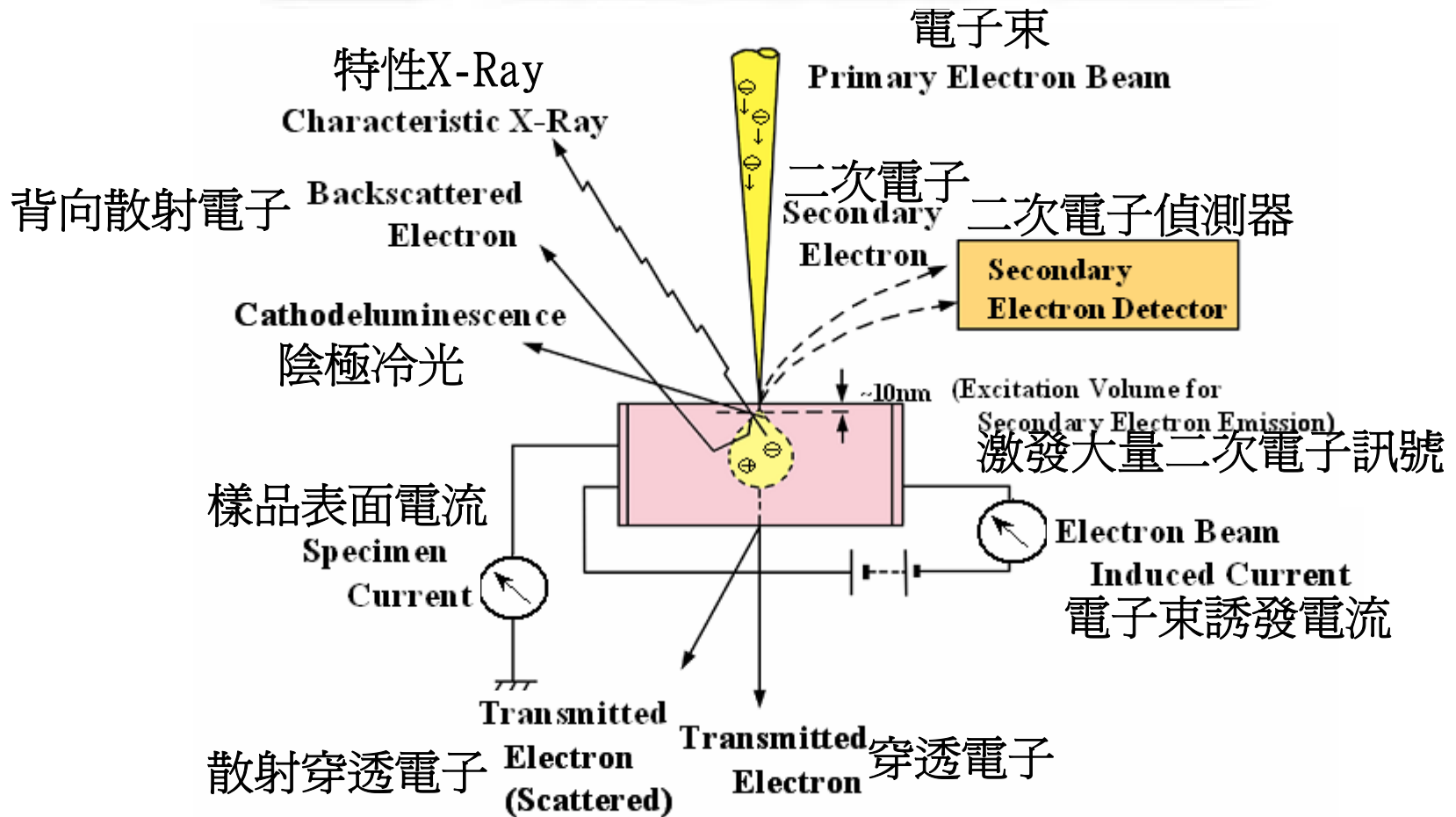
**The primary electron beam-specimen
interaction in the SEM**



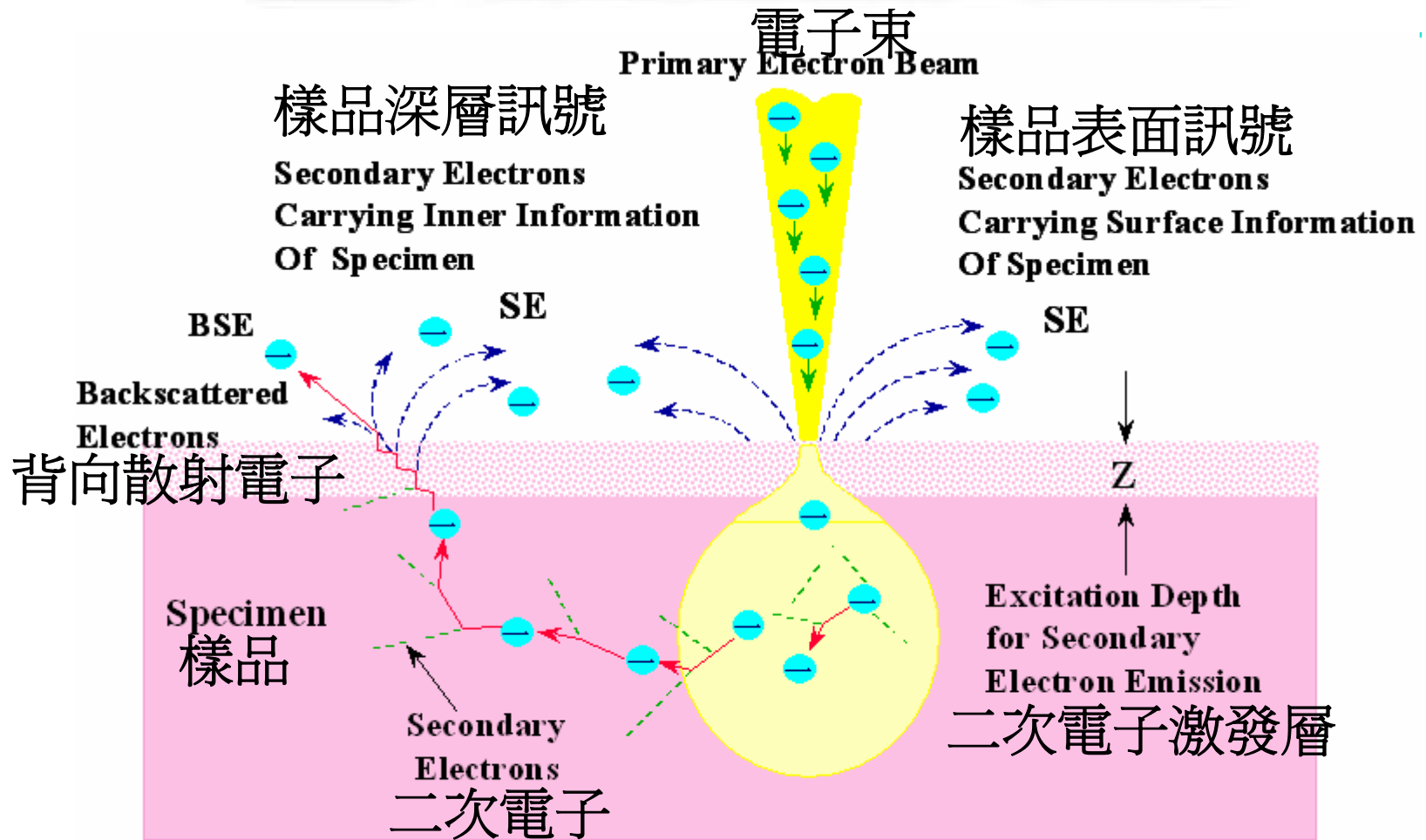
The primary electron beam-specimen interaction in the SEM



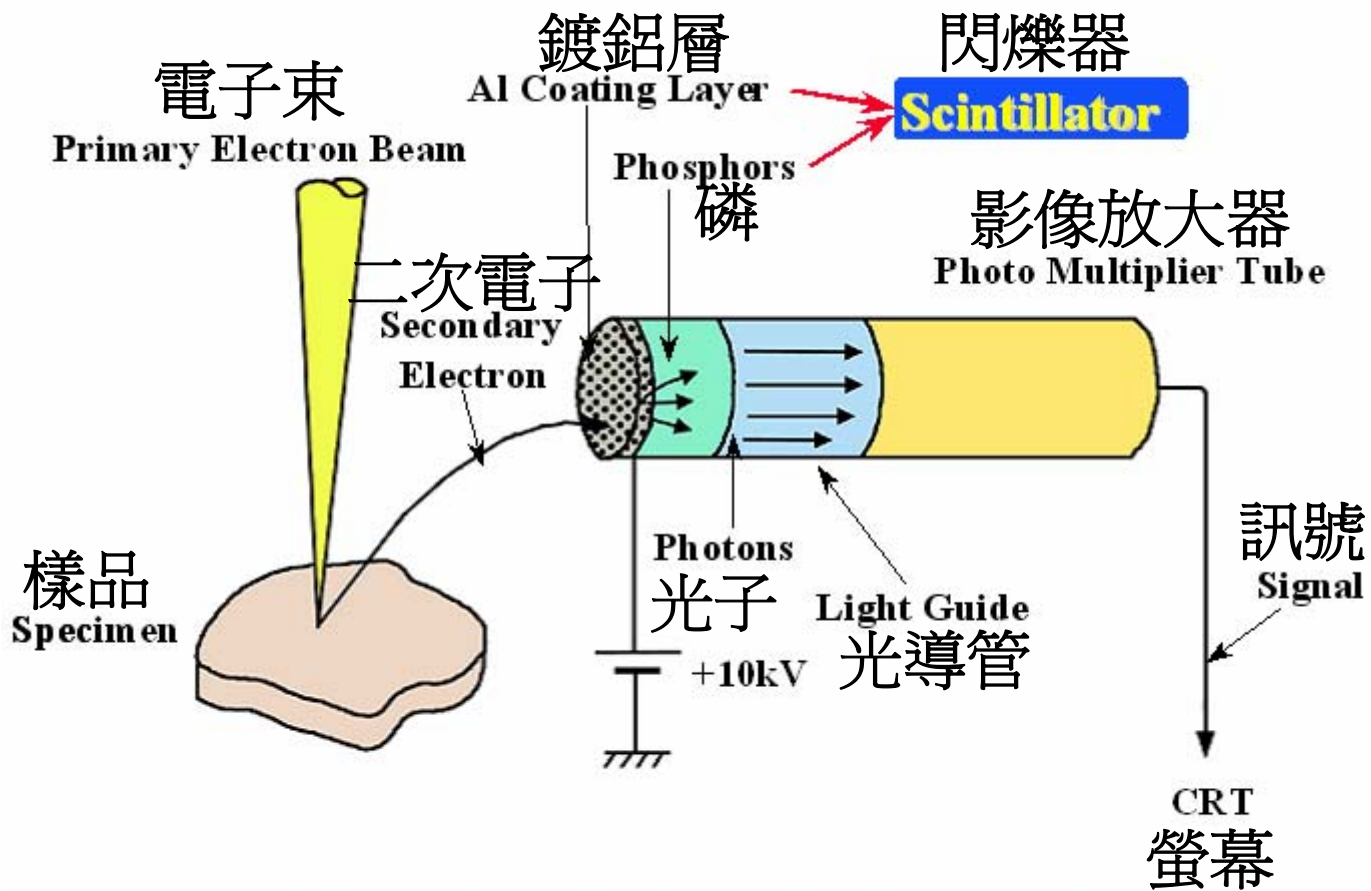
The primary electron beam-specimen interaction in the SEM



The primary electron beam-specimen interaction in the SEM

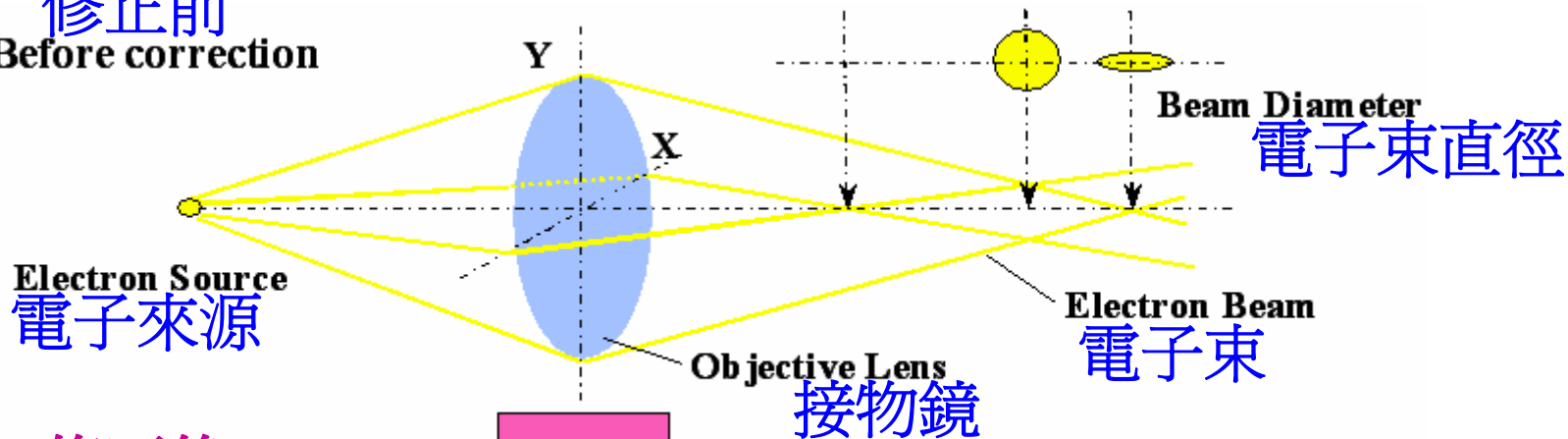


SE and BSE emitted from solid sample



Secondary electron detection system

修正前
Before correction

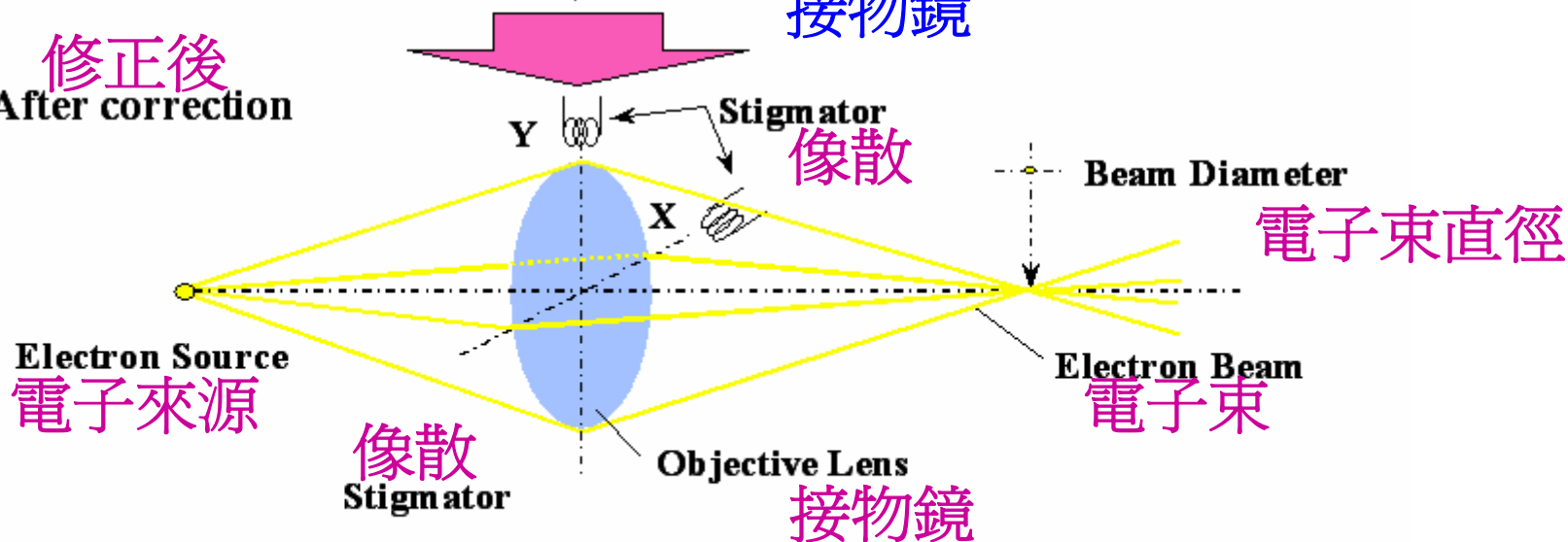


電子束直徑

電子束

接物鏡

修正後
After correction



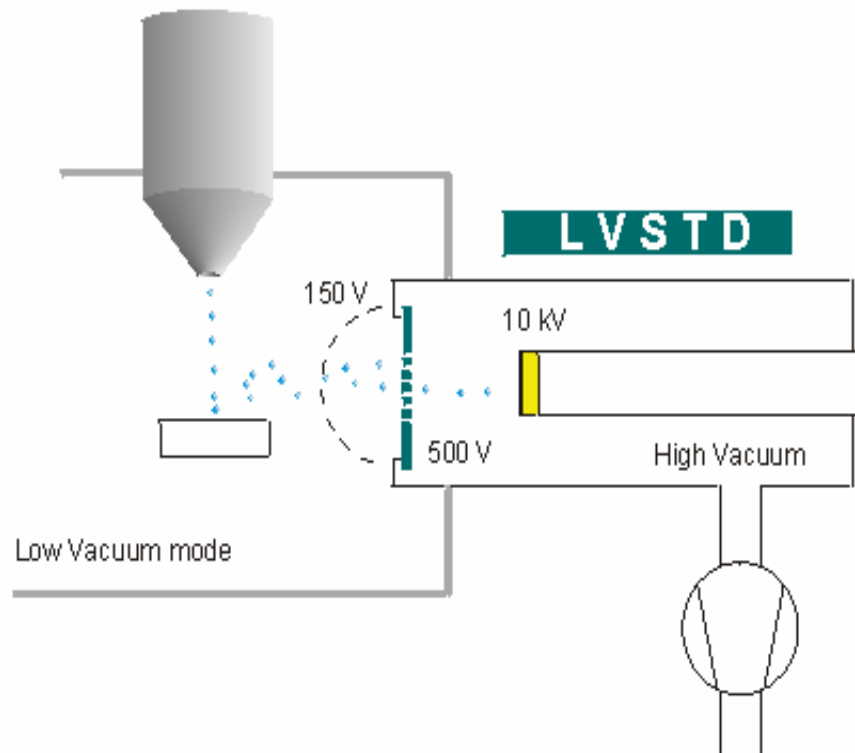
電子束直徑

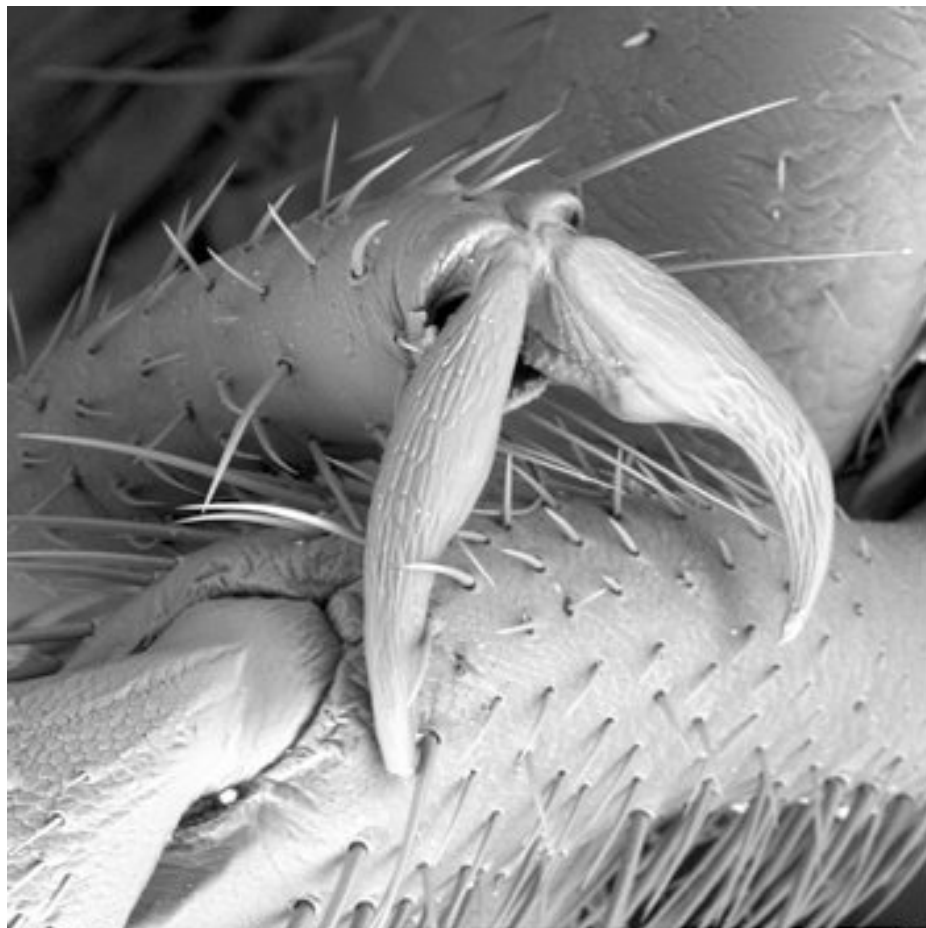
電子束

接物鏡

Astigmatism correction method

Low Vacuum Secondary Tescan Detector

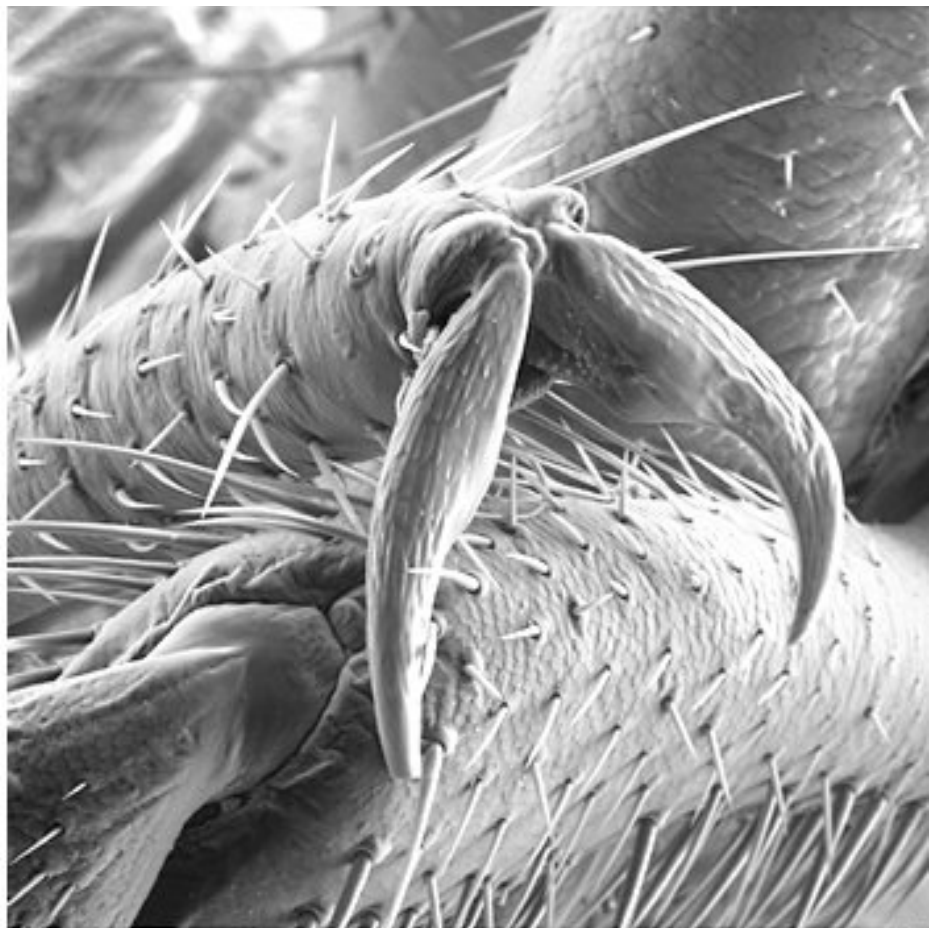




SEM MAG: 760 x
HV: 15.0 kV
VAC: LowVac, 80 Pa
DET: BSE Detector
DATE: 08/28/02
Device: TS5136MM

200 μ m

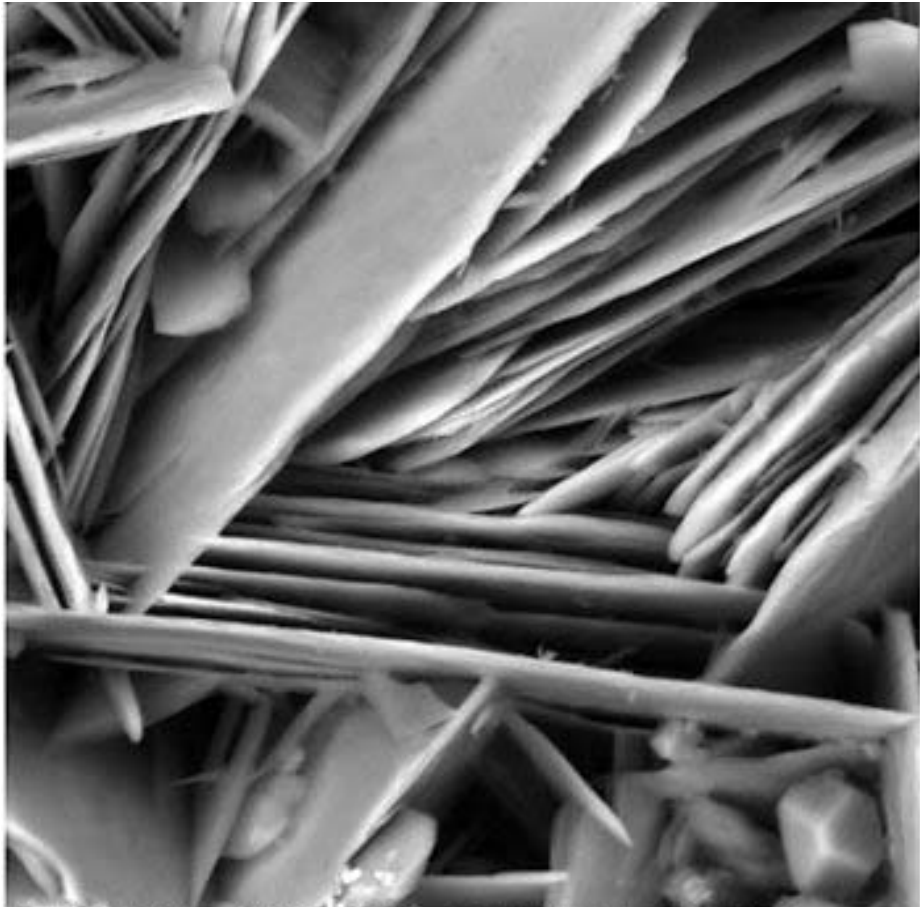
Vega ©Tescan
Digital Microscopy Imaging



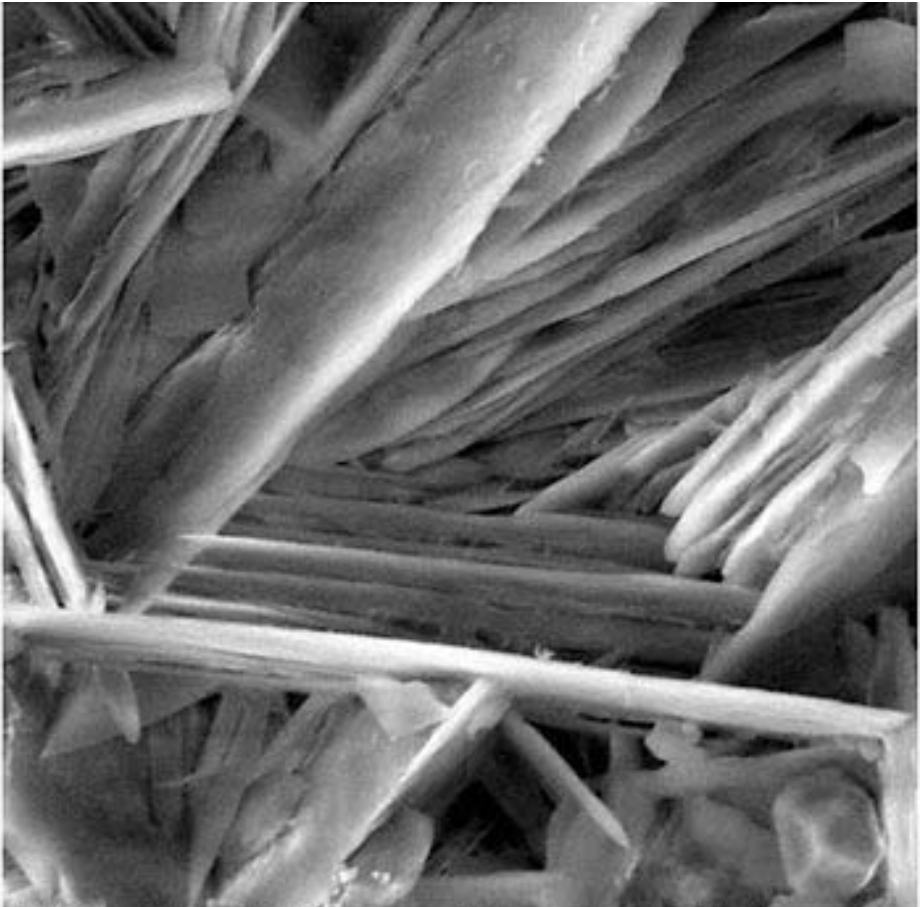
SEM MAG: 760 x
HV: 15.0 kV
VAC: LowVac, 80 Pa
DET: LVSTD
DATE: 08/28/02
Device: TS5136MM

200 μ m

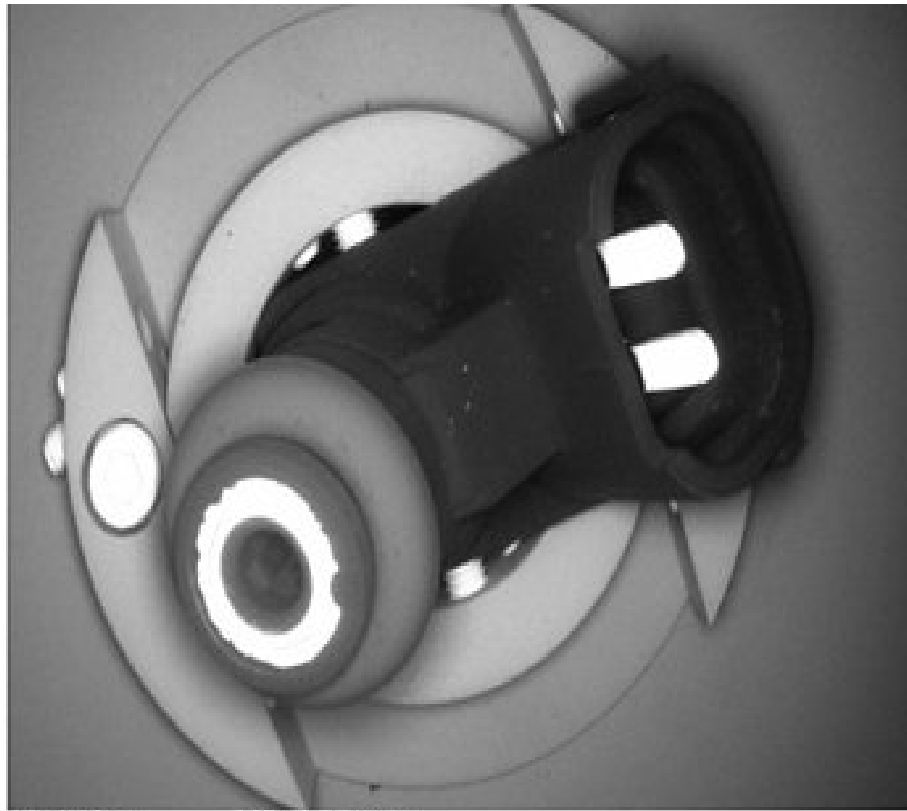
Vega ©Tescan
Digital Microscopy Imaging



SEM MAG: 1.13 kx DET: BSE Detector
HV: 30.0 kV DATE: 06/21/02 50 μ m
VAC: LowVac, 100 Pa Vega ©Tescan
Digital Microscopy Imaging

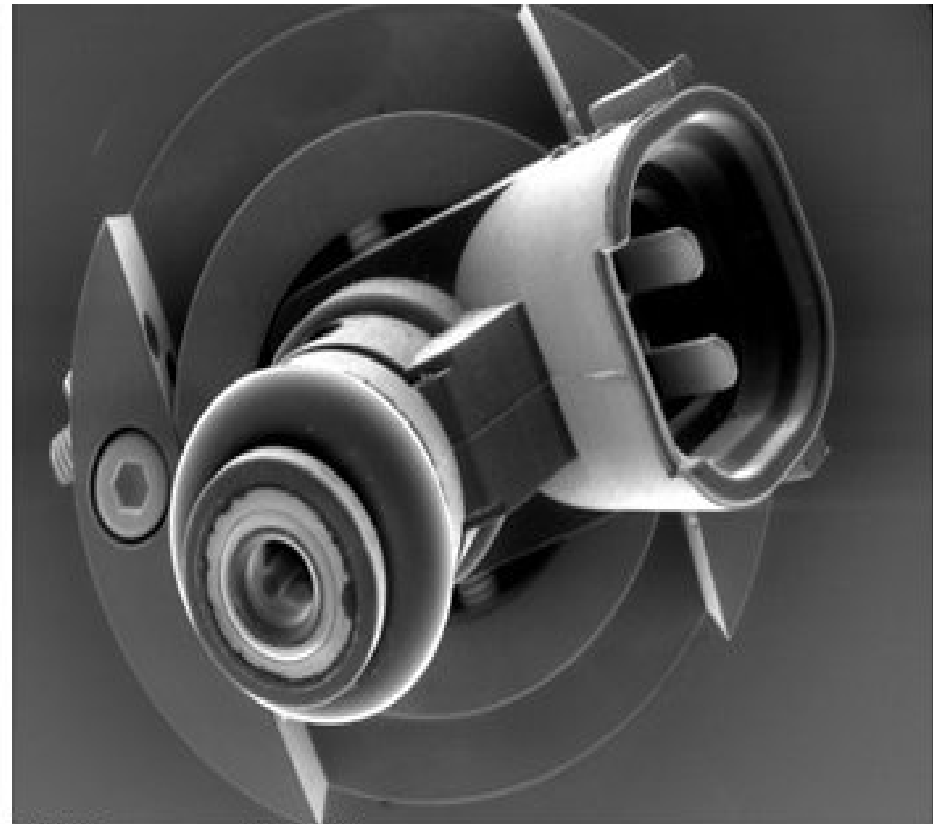


SEM MAG: 1.13 kx DET: LVSTD
HV: 30.0 kV DATE: 06/21/02 50 μ m
VAC: LowVac, 100 Pa Vega ©Tescan
Digital Microscopy Imaging



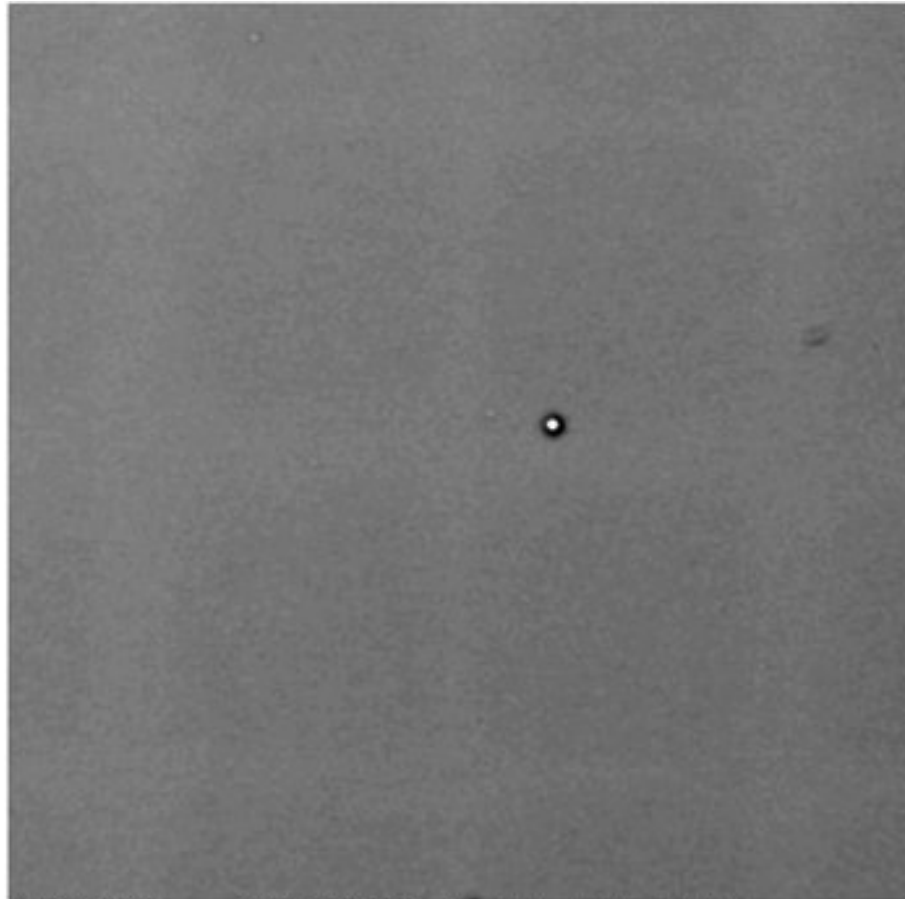
SEM MAG: ---
HV: 20.0 kV
VAC: LowVac, 15 Pa
DET: BSE Detector
DATE: 10/02/02
Device: TS5136XM

Vega ©Tescan
Digital Microscopy Imaging



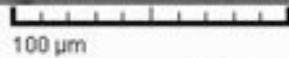
SEM MAG: ---
HV: 20.0 kV
VAC: LowVac, 15 Pa
DET: LVSTD
DATE: 10/02/02
Device: TS5136XM

Vega ©Tescan
Digital Microscopy Imaging



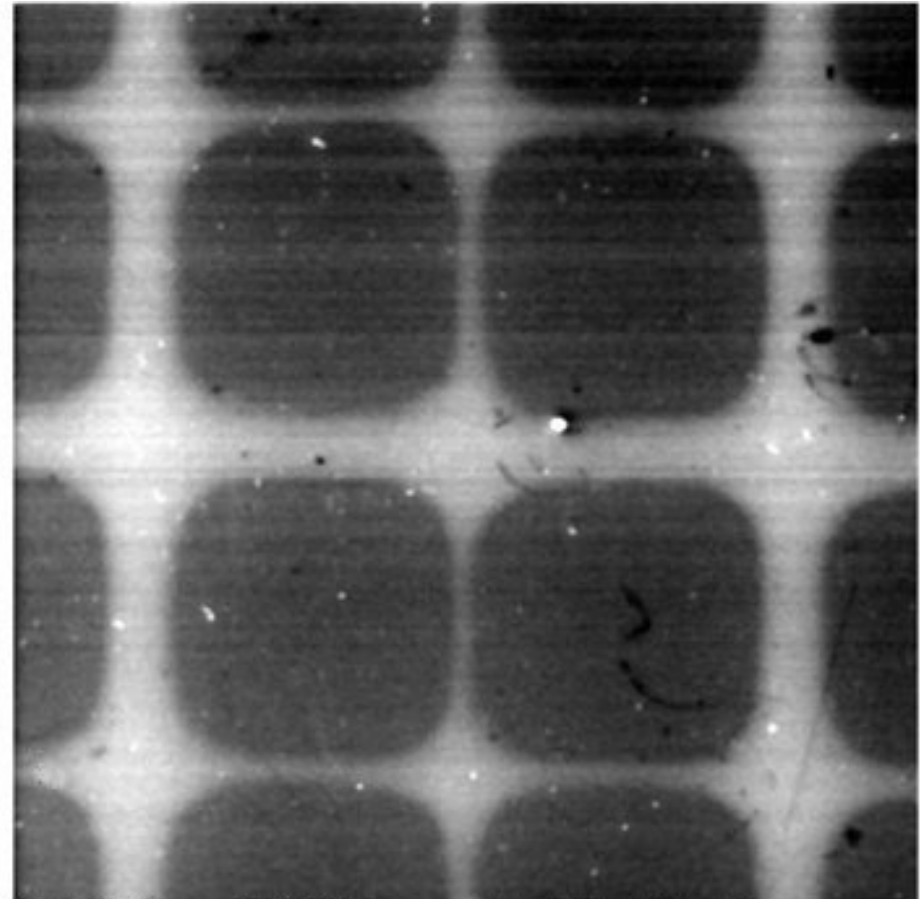
SEM MAG: 488 x
HV: 30.0 kV
VAC: LowVac, 20 Pa

DET: BSE Detector
DATE: 07/05/02



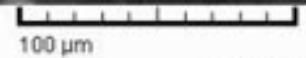
100 µm

Vega ©Tescan
Digital Microscopy Imaging



SEM MAG: 488 x
HV: 30.0 kV
VAC: LowVac, 20 Pa

DET: LVSTD
DATE: 07/05/02

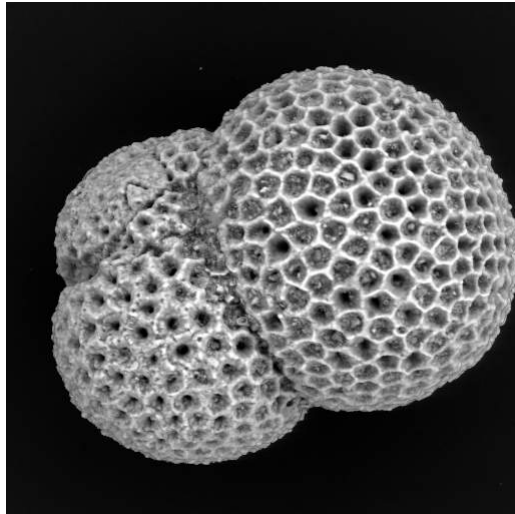


100 µm

Vega ©Tescan
Digital Microscopy Imaging

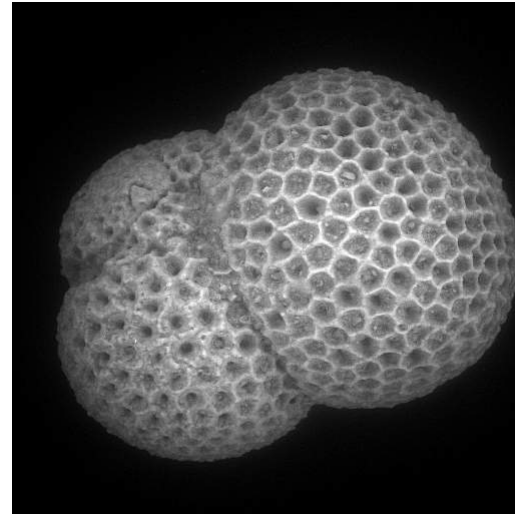
低真空影像比較圖(BSE)

50 pa



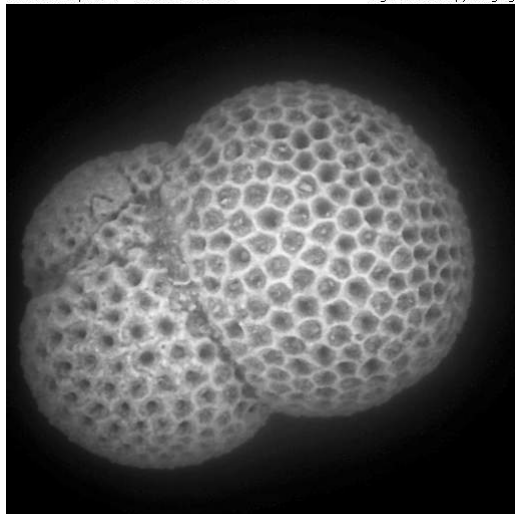
SEM MAG: 325 x DET: BSE Detector
HV: 30.0 kV DATE: 04/03/03
VAC: LowVac, 43 Pa Device: TS5136MM
200 µm Vega ©Tescan
Digital Microscopy Imaging

1000 pa



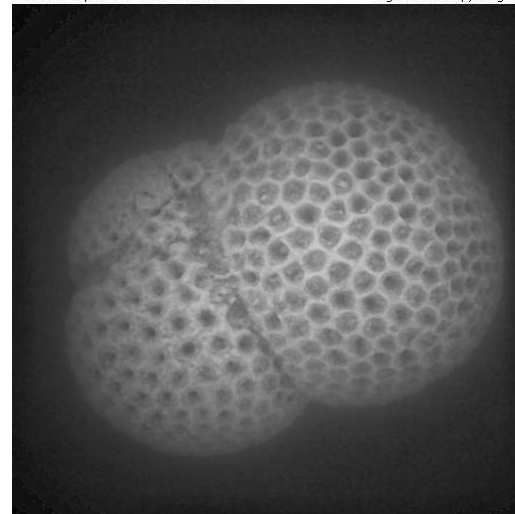
SEM MAG: 322 x DET: BSE Detector
HV: 30.0 kV DATE: 04/03/03
VAC: LowVac, 991 Pa Device: TS5136MM
200 µm Vega ©Tescan
Digital Microscopy Imaging

1500 pa



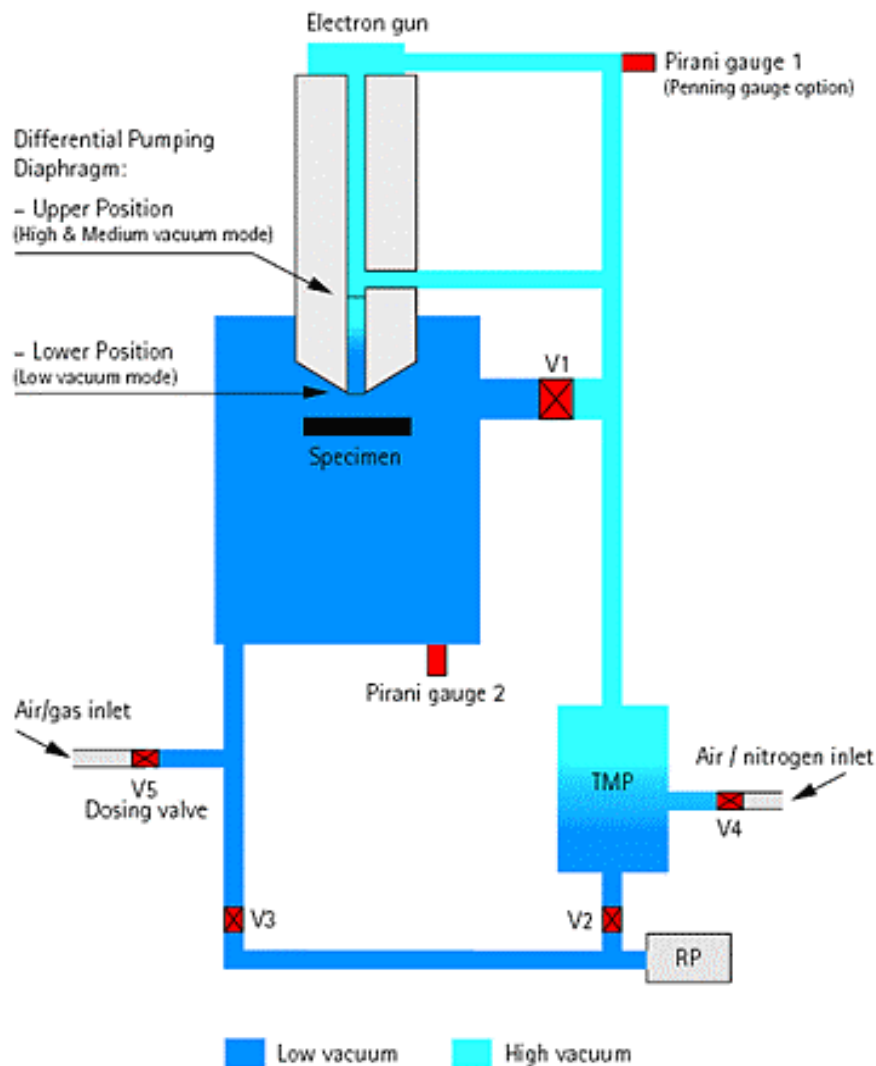
SEM MAG: 322 x DET: BSE Detector
HV: 30.0 kV DATE: 04/03/03
VAC: LowVac, 1489 Pa Device: TS5136MM
200 µm Vega ©Tescan
Digital Microscopy Imaging

2000 pa

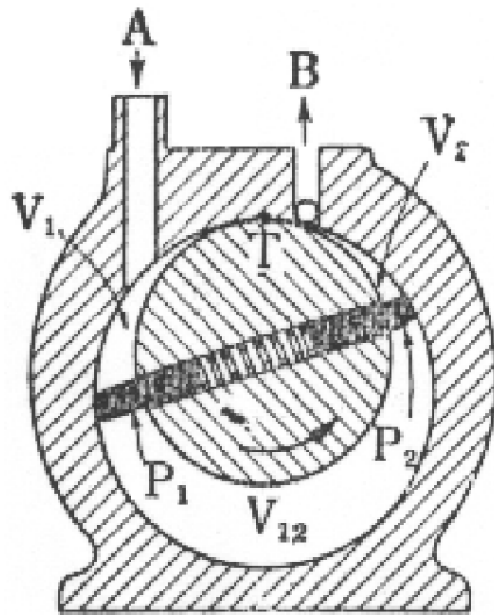


SEM MAG: 311 x DET: BSE Detector
HV: 30.0 kV DATE: 04/03/03
VAC: LowVac, 2018 Pa Device: TS5136MM
200 µm Vega ©Tescan
Digital Microscopy Imaging

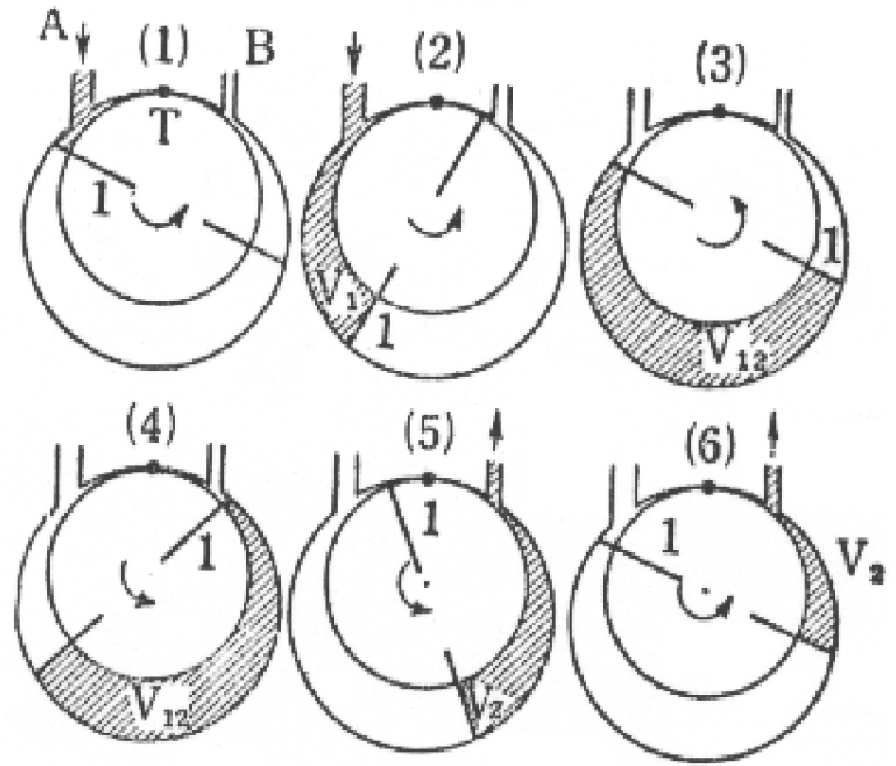
真空系統剖面圖



油迴轉式幫浦原理 (Oil Rotary Pump)

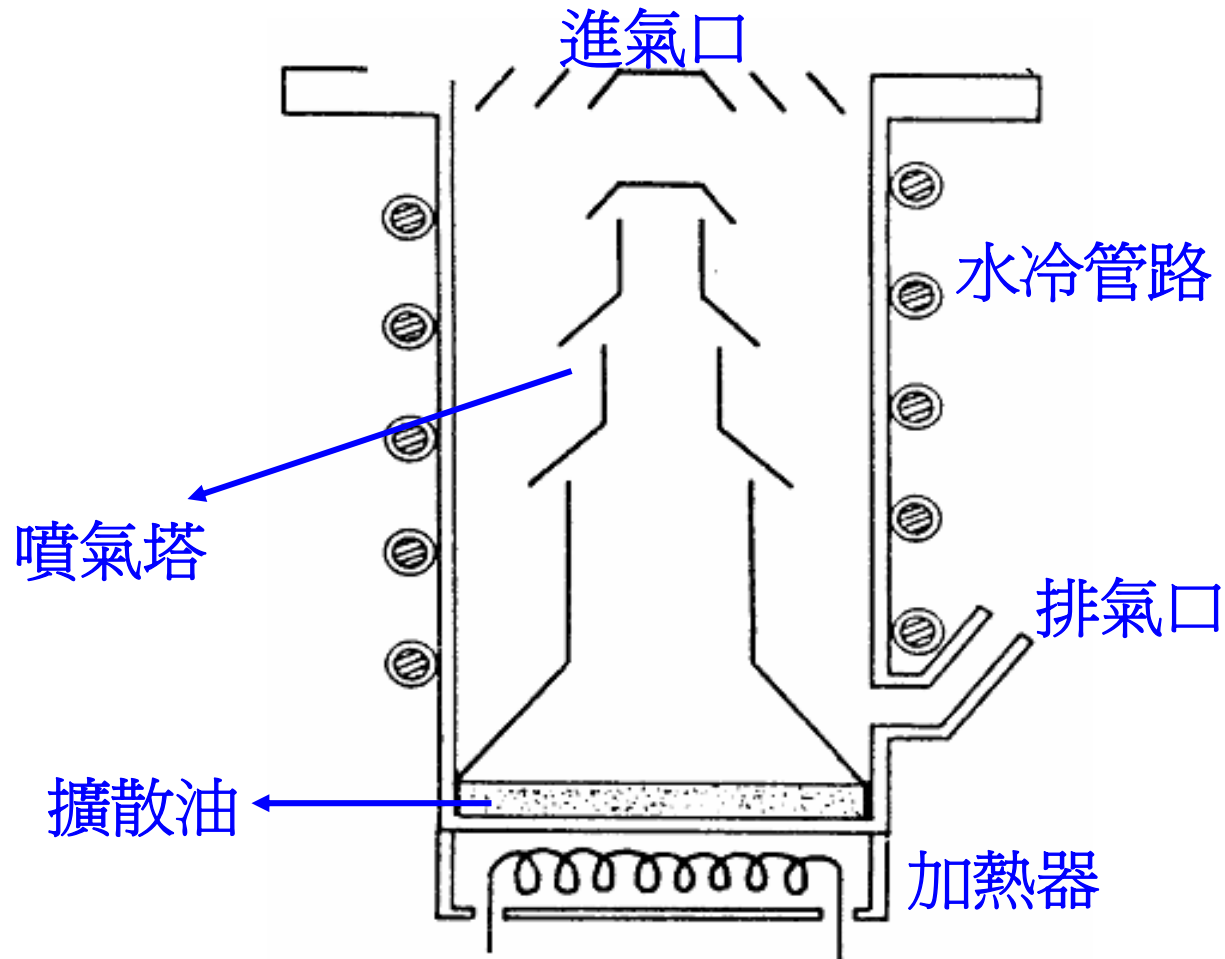


(a)



(b)

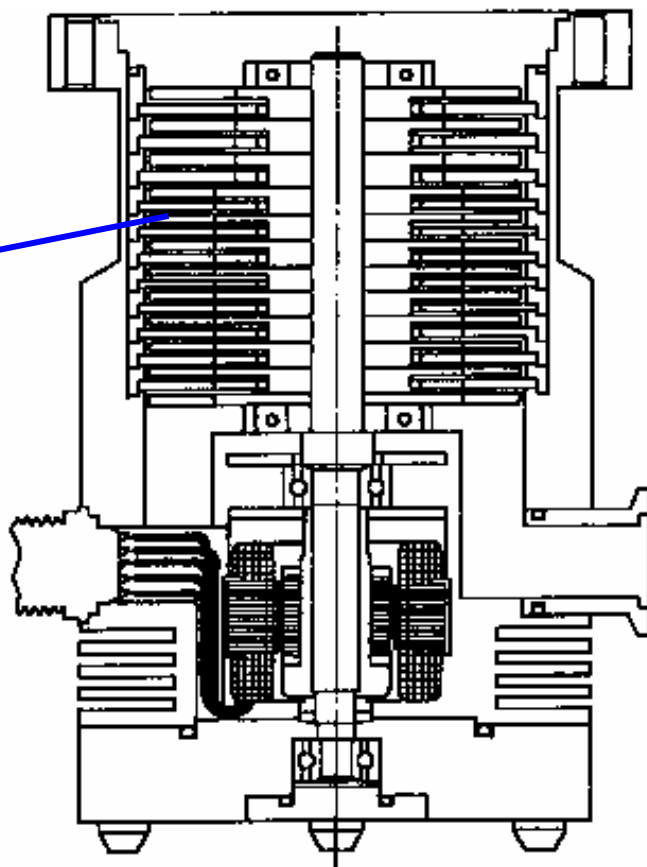
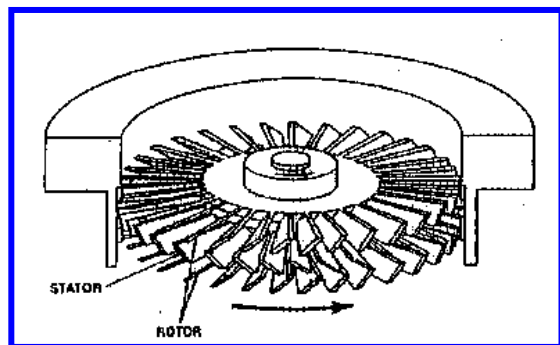
油擴散式幫浦構造 (Oil Diffusion Pump)



渦輪幫浦構造 (Turbo Molecular Pump)

進氣口

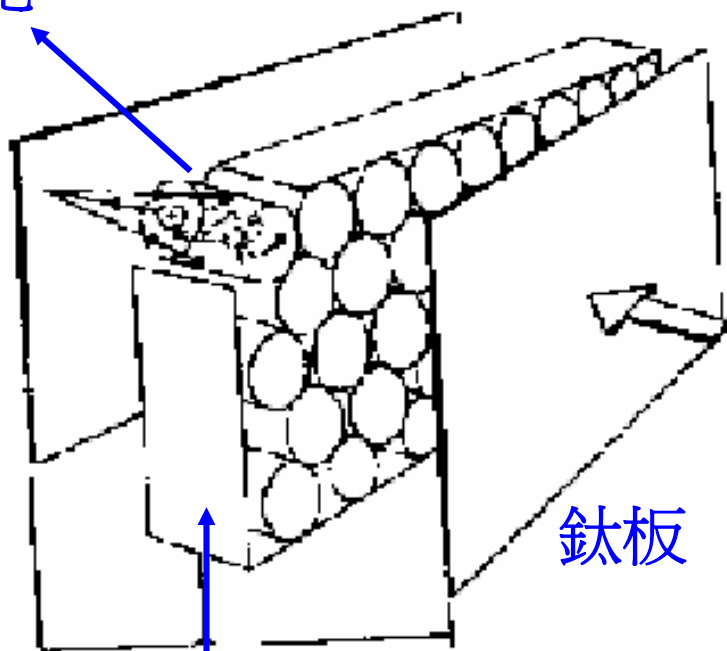
渦輪葉片



排氣口

離子幫浦構造 (Ion Pump)

氣體離子化



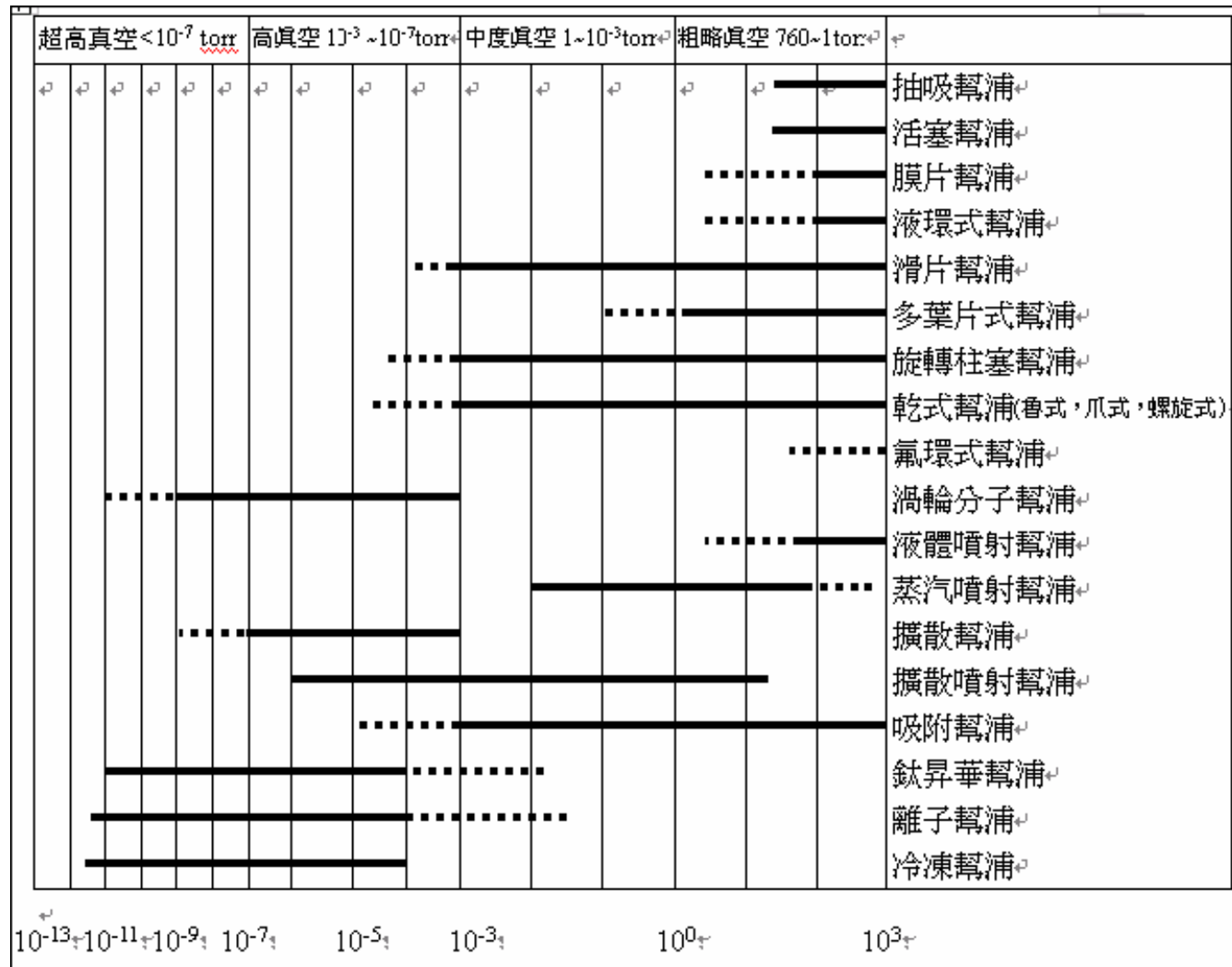
外加磁場

$B = 0.1T$

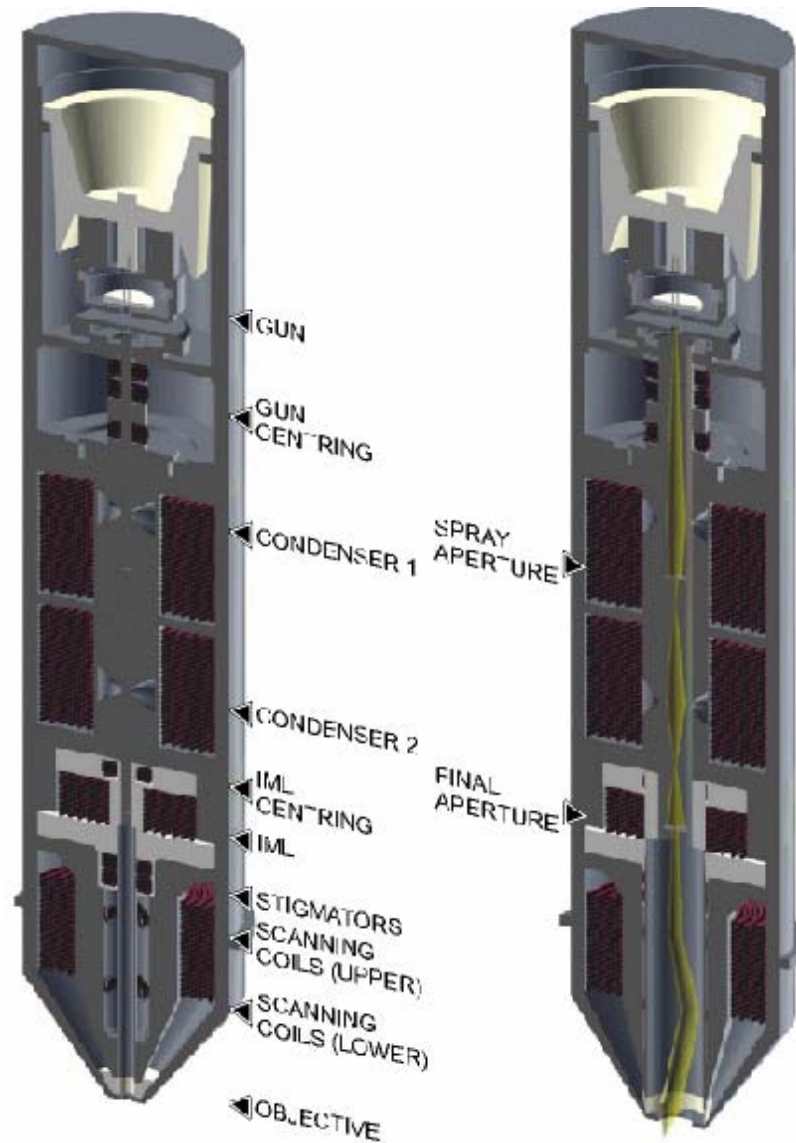
鈦板

高壓

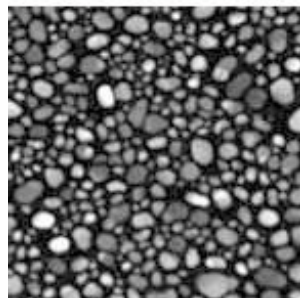
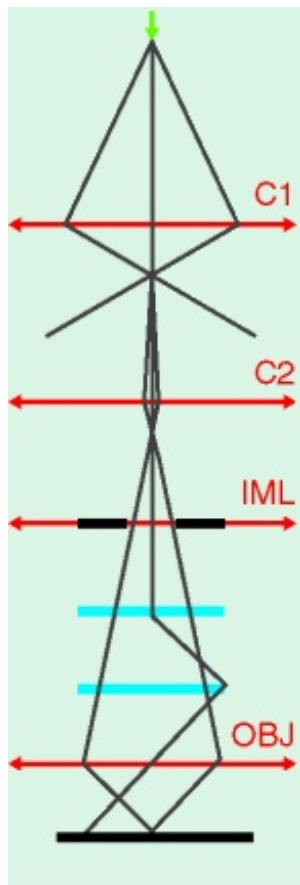
真空幫浦工作範圍比較表



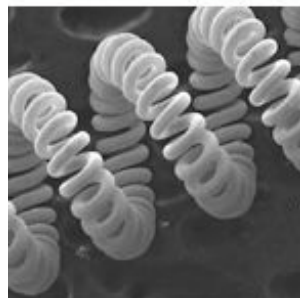
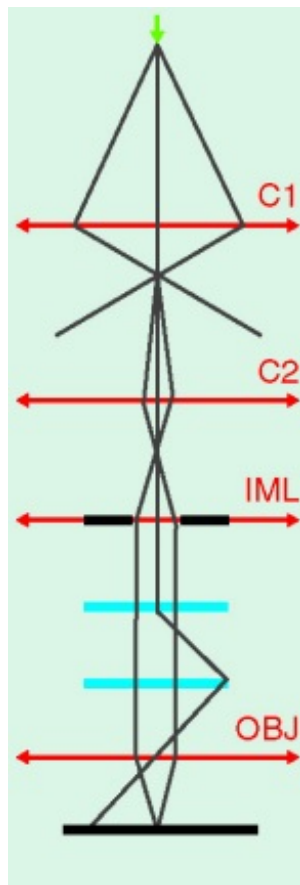
電子槍剖面圖



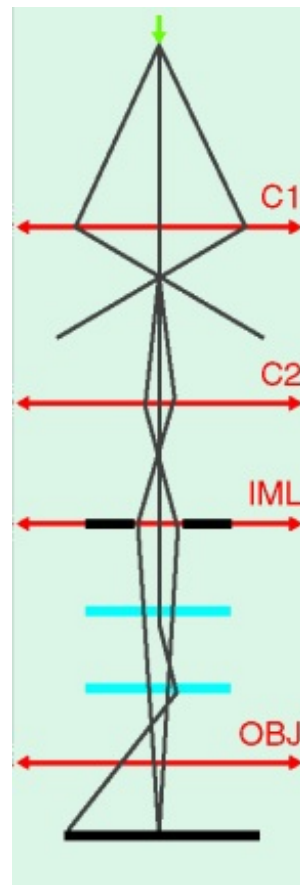
高解析模式



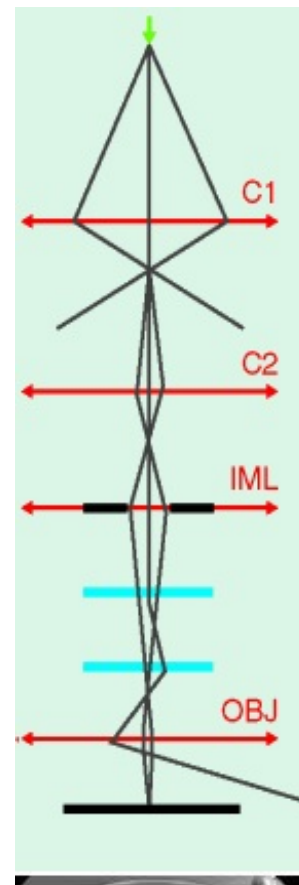
景深模式

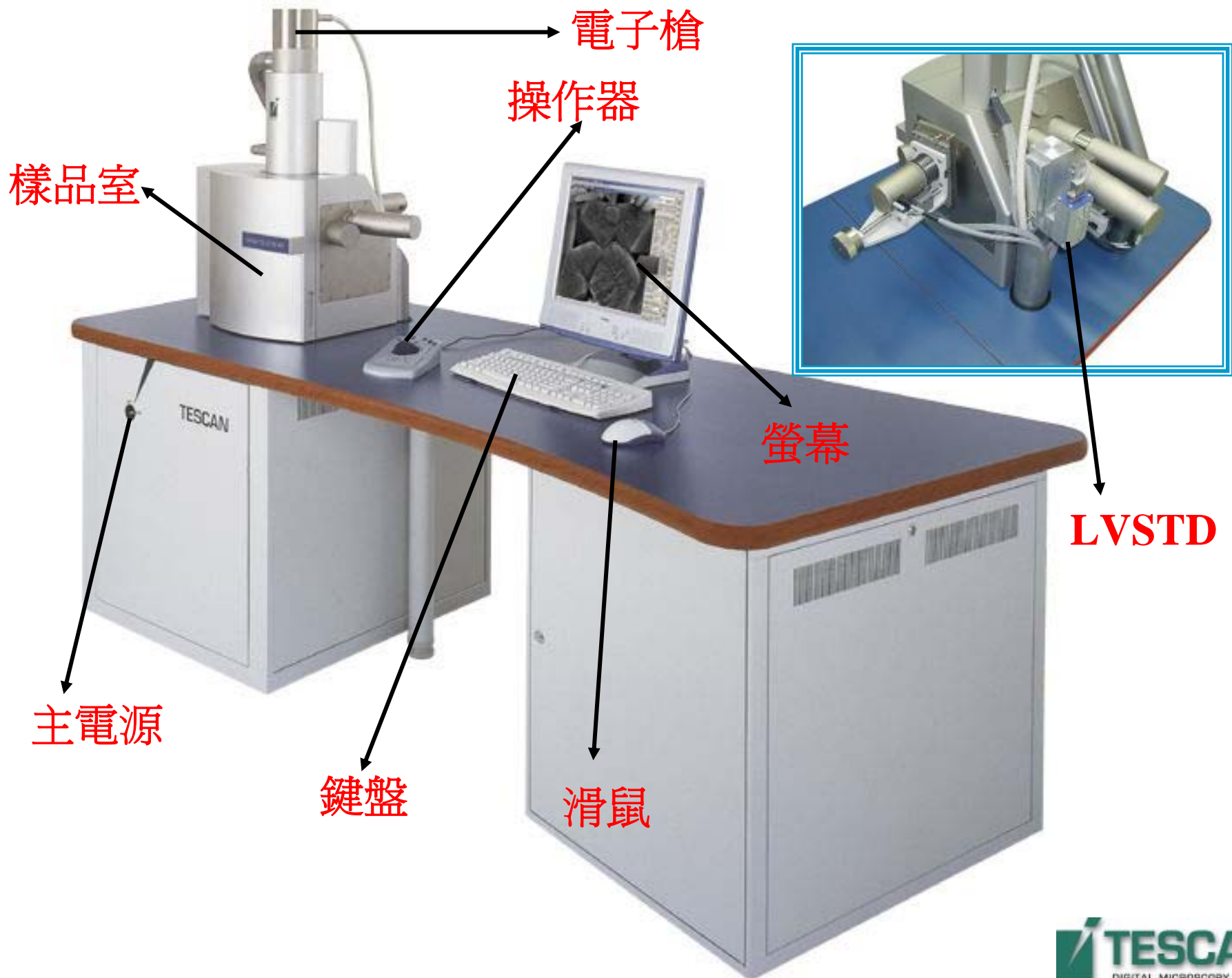


環境模式



魚眼模式





THE END

Presented by
Patrick Lee
Harvest Scientific Corporation

